Thesis/
Reports
Jensen,
S.

Pilot Study

Classification of Riverine/Riparian Habitat and Assessment of Nonpoint Source Impacts, North Fork Humboldt River, Nevada

Pilot Study

CLASSIFICATION OF RIVERINE/RIPARIAN HABITAT *and* ASSESSMENT OF NONPOINT SOURCE IMPACTS, NORTH FORK HUMBOLDT RIVER, NEVADA

•§•

WHITE HORSE ASSOCIATES
SMITHFIELD, UTAH

Pilot Study

CLASSIFICATION OF RIVERINE/RIPARIAN HABITAT *and* ASSESSMENT OF NONPOINT SOURCE IMPACTS, NORTH FORK HUMBOLDT RIVER, NEVADA

•§•

Prepared for:

USDA FOREST SERVICE
INTERMOUNTAIN RESEARCH STATION
BOISE FISHERIES UNIT

by

SHERMAN JENSEN [1]
RON RYEL
WILLIAM S. PLATTS [2]

December, 1989

1 White Horse Associates / Box 123 / Smithfield, UT 84335
2 Don Chapman Consultants, Inc. / 3180 Airport Way / Boise, ID 83705

ACKNOWLEDGMENTS

This study was made possible by many individuals. Principal Scientists were Dr. William S. Platts (Fishery Biologist), Frank Smith (Botanist), Ron Ryel (Systems Analyst/Data Manager) and Sherman Jensen (Soil Scientist/Physical Ecologist). Fishery and stream attributes were measured by Chris Carlson, Craig Contour, Craig Hoover, Mark James and Scott Spalding. Ted Dean was assisted by Todd Hougaard and Lloyd Mendes in application of a Geographical Information System (GIS). Suzanne Thorson entered field data on the computer and helped compile reports. Roger Nelson and Jack Van Deventer (Intermountain Research Station) organized fishery crews and facilitated transfer of existing data. Jerry Hughes drafted many of the figures and Chip Rawlins edited the report. Dr. Jack Griffith was pilot of the aerial reconnaissance.

Willow identifications were verified by Dr. Robert Dorn. Glen DeVoe (Idaho Falls District BLM), Dennis Tol (Winnemucca District BLM) and John Kaywood (Humboldt National Forest, Buhl, ID) were instrumental for identifying reference stations. Karl Gebhardt (BLM, Boise Regional Office) and Dan Carpenter (Elko District Forest Service) were consulted concerning hydrologic matters. Personnel from the Elko District BLM (Carol Evans, Laura Geizer, Steve Kiracofe and Roy Price) and the Nevada Department of Wildlife (Gene Weller and Gary Johnson) served as sounding boards and provided useful suggestions. Phil Larsen (EPA, Corvallis, OR) reviewed drafts and suggested revisions. Many anonomous scientists reviewed the draft of this document, identifying areas needing revision or clarification.

We thank these individuals and credit them for furthering our understanding of the structure, function and values of stream and riparian habitats.

TABLE OF CONTENTS

		PAGE
1.0	INTRODUCTION	1
2.0	SCOPE	3
2.1	Approach	4
2.2	Geographical Overview	6
2.3	Pilot Watershed	16
3.0	METHODS	21
3.1	Hierarchical Classification	21
3.2	Inventory of Riverine/Riparian Habitat	28
3.3	Inventory of Landforms and Vegetation Types	29
3.4	Attributes of Riverine/Riparian Habitat	30
3.5	Synthesis and Interpretation	35
4.0	CLASSIFICATION AND INVENTORY	36
4.1	Ecoregion	47
4.2	Geologic Districts	49
4.3	Landtype Associations	58
4.4	Landtype	66
4.5	Valley-Bottom Types	68
4.6	Landforms	79
4.7	Vegetation Types	85
5.0	ASSESSMENT OF RIVERINE/RIPARIAN HABITAT	98
5.1	Width of Streambars as Affected by Grazing	98
5.2	Assessment Relative to Reference Stations	106
5.3	Assessment Relative to a Progression of States	113
5.3.1	Condition Rating for Flowing Streams.	118
5.3.2	Condition Rating for Dry Stations	140
5.3.3	Condition Rating using GAWS Data	141
5.4	Assessment of Vegetative Attributes	143
5.5	Assessment of Fish Attributes	145
6.0	SUMMARY	151
6.1	Classification Summary	152
6.2	Assessment Summary	158
7.0	LITERATURE CITED	161

LIST OF APPENDICES

APPENDIX A - EXEMPLARY FIELD FORMS
APPENDIX B - STREAM ATTRIBUTES FOR GEOLOGIC DISTRICTS
APPENDIX C - STREAM ATTRIBUTES FOR LANDTYPE ASSOCIATIONS
APPENDIX D - STREAM ATTRIBUTES FOR VALLEY-BOTTOM TYPES
APPENDIX E - STREAM ATTRIBUTES FOR BANK-FORMING LANDFORMS
APPENDIX F - PLANT NAMES AND CHARACTER
APPENDIX G - PLANT ASSOCIATION TABLE
APPENDIX H - DATA SUMMARY, LIVESTOCK/FISHERY STUDY AREAS
APPENDIX I - DATA SUMMARY FOR SURVEY STATIONS
APPENDIX J - COEFFICIENTS OF DISCRIMINANT FUNCTIONS
APPENDIX K - QUALITY ASSURANCE/QUALITY CONTROL
APPENDIX L - LEGENDS
APPENDIX M - DESCRIPTIONS OF VEGETATION TYPES
APPENDIX N - PROCESSES INFLUENCING RIVERINE/RIPARIAN HABITAT

LIST OF TABLES

2.3-1. Stream attributes, North Fork Humboldt study area.
2.3-2. Ownership status, North Fork Humboldt study area.
4.0-1. Hierarchical levels of classification.
4.2-1. Geologic districts, North Fork Humboldt study area.
4.2-2. Rock types comprising geologic districts (Coats 1987).
4.2-3. Stream attributes for geologic districts.
4.2-4. Drainage density for geologic districts.
4.3-1. Landtype association legend, North Fork Humboldt study area.
4.3-2. Stream attributes for landtype associations.
4.4-1. Area of the valley-bottom within landtype associations.
4.5-1. Valley-bottom types, North Fork Humboldt study area.
4.5-2. Stream attributes for valley-bottom types.
4.7-1. Legend of vegetation types, North Fork Humboldt study area.
5.1-1. Valley-bottom type (VBT) and treatments of stations for LFSAs in Nevada and Utah.
5.1-2. Mean width of streambars and eroded banks for various bank-forming vegetation types.
5.2-1. Attributes potentially sensitive to nps impacts selected from LFSAs for comparison between control and treatment stations.
5.2-2. Means (+ std. dev.) of four attributes measured within four landforms of LFSAs.
5.2-3. Assessments of LFSA stations, relative to preliminary reference stations.
5.3-1. Attributes used to assess transects and results of preliminary clustering of two randomly selected sets of stations in 1210 and 1220 VBTs.
5.3-2. Condition ratings for 21 stations in Set 1 from 1210 and 1220 VBTs.
5.3-3. Condition ratings for 21 stations in Set 2 from 1210 and 1220 VBTs.
5.3-4. Condition rating for 42 stations in 1210 and 1220 VBTs determined from clustering and discriminant functions using 11 attributes, dry channel attributes and GAWS attributes.
5.3-5. Ranking and synopsis of management for stations located in fluvial lands in the sedimentary geologic district (1210 and 1220 VBTs).
5.3-6. Condition rating for stations in fluvial (V-shaped) lands in the volcanic geologic district (2210 and 2220 VBTs) calculated from clustering, discriminant function, dry station attributes and GAWS attributes, and differences from the cluster rating.
5.3-7. Condition rating for stations in alluvial lands (3310 and 3320 VBTs) calculated from clustering, discriminant function, dry station attributes and GAWS attributes, and differences from the cluster rating.
5.3-8. Condition rating for stations in glacial basins (1110 VBT) calculated from clustering, discriminant function, dry station attributes and GAWS attributes, and differences from the cluster rating.
5.3-9. Condition rating for stations in glacial trains (1120 VBT) calculated from clustering discriminant function, dry station attributes and GAWS attributes, and differences from the cluster rating.

LIST OF TABLES (CONTINUED)

5.3-10. Condition rating for stations in glacial outwash (1130 VBT) calculated from clustering, discriminant function, dry station attributes and GAWS attributes, and differences from the cluster rating.

5.3-11. Condition rating for stations in fluvial (notch-shaped) canyons in the volcanic geologic district (2250 and 2260 VBTs) calculated from clustering discriminant function, dry station attributes and GAWS attributes, and differences from the cluster rating.

5.3-12. Ratings calculated from clustering of all stations of non-glacial lands with flowing streams.

5.3-13. Ratings calculated from clustering of all stations in glacial lands.

5.3-14. Ratings, derivation of each rating and the percent of cross-sections with a given score for all survey stations.

5.3-15. Attributes that could be measured for stations that were dry; attributes that are measured for typical GAWS (Level II) inventories; and attributes used for cluster and discriminant analyses of stations in glacial lands.

5.4-1. Percent distribution of scores for vegetation types identified on transects of 110 survey stations.

5.5-1. Average trout biomass for survey stations in the NFH study area, sorted by valley-bottom type.

5.5-2. Summary of fish attributes for five streams in the NFH study area where trout were found.

5.5-3. Results of tests for correlation between trout biomass/unit area and condition ratings of survey stations where trout were present.

LIST OF FIGURES

2.2-1. Great Basin Section of the Basin and Range Physiographic Province (Fenneman 1931)
2.2-2. Evolution of geologic structure of the Great Basin (Hunt 1974).
2.2-3. Geomorphic evolution of fault block landscape (modified from Fenneman 1931).
2.2-4. Subdivisions of the Great Basin Physiographic Section (Hunt 1974).
2.2-5. Subregions of the Great Basin Hydrographic Region.
2.2-6. Hydrographic units of the Lahontan Basins Subregion.
2.2-7. Sections of the Great Basin Floristic Division (Cronquist et al. 1972).
2.3-1. North Fork Humboldt study area (map).
2.3-2. Surface management, North Fork Humboldt study area (map).
3.1-1. Water regimes.
3.4-1. Survey stations, North Fork Humboldt study area (map).
3.4-2. Survey stations outside the North Fork Humboldt study area (map).
4.0-1. Map levels for hierarchical classification.
4.0-2. Exemplary application of the hierarchical classification.
4.0-3. Conventions of coding system.
4.1-1. Ecoregions of the western United States (Omernik 1986).
4.2-1. Geologic districts, North Fork Humboldt study area (photos).
4.2-2. Geologic districts, North Fork Humboldt study area (map).
4.3-1. Geomorphic classes, North Fork Humboldt study area (photos).
4.3-2. Geomorphic classes, North Fork Humboldt study area (map).
4.3-3. Landtype associations, North Fork Humboldt study area (map).
4.4-1. Valley-bottom landtype, North Fork Humboldt study area (map).
4.5-1. Valley-bottom types, glacial land (photos).
4.5-2. Valley-bottom types, fluvial land (photos).
4.5-3. Valley-bottom types, alluvial land (photos).
4.5-4. Valley-bottom types, North Fork Humboldt study area (map).
4.5-5. Percent distribution of stream gradient.
4.6-1. Typical distribution of landforms in glacial valley-bottoms.
4.6-2. Typical distribution of landforms in fluvial valley-bottoms.
4.6-3. Typical distribution of landforms in alluvial valley-bottoms.
4.7-1. Herbaceous vegetation types.
4.7-2. Willow dominated vegetation types.
4.7-3. *Populus tremuloides*/mesic herbaceous RPT.
4.7.4. Upland shrub vegetation types.
4.7-5. Riverine types.
5.1-1. Mean widths of RVTs in grazed and rested pastures of four Livestock/Fishery Study Areas in northern Nevada.
5.1-2. Mean widths of RVTs in grazed and rested pastures of two Livestock/Fishery Study areas in northern Utah.
5.3-1. Progression of states leading to an incised channel.
5.3-3. Distribution of states for three survey stations in relatively good (WT01), fair (GZSA3) and poor (MH05A) condition.
5.3-4. Percent of transects rated correctly by discriminant functions generated using 1 to 11 attributes.
5.3-5. Survey stations.

LIST OF ACRONYMS

AOV	Analysis of Variance
AQT	Aquatic type
BLM	Bureau of Land Management
CB	Cobble bar
CWA	Clean Water Act
EB	Eroded bank
EPA	Environmental Protection Agency
GAWS	General Aquatic Wildlife Survey
GB	Gravel bar
GD	Geologic district
GIS	Geographical Information System
HCB	Herbaceous cobble bar
HSB	Herbaceous sand bar
HGB	Herbaceous gravel bar
HSIB	Herbaceous silt bar
LFSA	Livestock/fishery study area
MCT	Miscellaneous type
MF	Mesic forb
MH	Mesic herbaceous
MJR	Major
mn	Mean
MNR	Minor
ms	Mean square
NFH	North Fork Humboldt
nps	Non-point source
RPT	Riparian type
RRE	Riverine/riparian ecosystem
RRH	Riverine/riparian habitat
RVT	Riverine type
SB	Sand bar
SCS	Soil Conservation Service
sd	Standard deviation
SIB	Silt bar
ss	Sum of squares
UPT	Upland type
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VBT	Valley-bottom type
WQS	Water Quality Standards

This page is intentionally blank.

1.0 INTRODUCTION

This study suggests an approach for identifying riverine/riparian habitat (RRH) of distinctive ecological potential and for assessing nonpoint source (nps) impacts. The approach was tested in the watershed of the North Fork Humboldt River in northern Nevada. The approach can be used to evaluate the effectiveness of management and to assess compliance with laws written to preserve or enhance the values of stream and riparian resources. This document will be most useful to land managers working in the North Fork Humboldt River basin and similar settings in northern Nevada. While classes of RRH are specific to the pilot watershed and assessment criteria are specific to livestock grazing, the approach to classification and assessment will be applicable to other areas and land uses.

The Clean Water Act (CWA) is a mandate to restore and maintain the chemical, physical and biological integrity of the nation's water. Methods for evaluating point source impacts to water quality have been established. Chemical attributes are monitored and compared with criteria that are potentially limiting to the attainment of beneficial uses.

Nonpoint sources are those for which the source or cause may not be readily identifiable and for which the mechanisms influencing aquatic resources are not readily quantifiable. Criteria for assessing nps impacts have not been developed. Many states have claimed that nps impacts prevent compliance with the CWA.

The inability to predict attainment of water quality standards (WQS) where nonpoint source activities are involved has prompted the EPA to suggest an iterative process for controlling nps pollution. This policy (SAM-32) will be part of the WQS Handbook which is currently under revision. This policy requires management to protect water quality and designated uses. The policy further requires that physical, chemical, and biological

information be evaluated to determine if management has attained the WQS. If WQS are not attained, the States may require that management practices including nps controls be modified or that the nps activity be ceased.

Temporal and spatial diversity complicates assessment of nps impacts to stream and riparian habitats. Different nps impacts (e.g. grazing versus logging) can influence the physical, chemical and biological integrity of a RRH through different mechanisms; likewise, differences in the structure and function of a RRH may result in different responses to the same nps impact. At present, management agencies have difficulty proving whether statutory requirements have been attained because there are few standards for comparison. A valid, tested scientific approach is needed for evaluating nps impacts to RRH.

Some terms are defined as follows:

Riverine ecosystem: land and water contained within the channel of a stream; includes streambanks, streambars and the streambottom; substrates are sediment with little soil development; **riverine habitat** is a functional subset of the riverine ecosystem.

Riparian ecosystem: "land transitional between aquatic and upland ecosystems that is characterized by hydric soil and distinctive vegetation (i.e. hydrophytes) requiring free or unbound water" (Bureau of Land Management 1986); **riparian habitat** is some functional subset of the riparian ecosystem.

Riverine/riparian ecosystem (RRE): the combined riverine and riparian ecosystems; for a given watershed there is usually a single RRE extending from headwaters to mouth.

Riverine/riparian habitat (RRH): some functional subset of a RRE that includes areas of similar **potential or achievable state**; this concept is generic and can be defined by the observer; the diversity within RRH varies as a function of the scale at which it is identified.

Riverine type: a discrete subset of riverine habitat that is identified by stream and channel attributes; a riverine type includes habitats of similar **existing state.**

Riparian type: a discrete subset of riparian habitat that is identified by floristic, soil and hydrologic attributes; a riparian type includes habitats of similar **existing state.**

Riverine/riparian habitat (RRH) can be identified from different perspectives. A hydrologist may identify it as within an large area of distinctive climate or stream dynamics; a geologist, as a smaller area of distinctive parent material or geomorphic character; a biologist, as a discrete complex of potential plant communities or habitat for fish and wildlife. A broad perspective and general criteria can serve as context for refined perspectives and discrete criteria. The biologist may develop a better understanding of plant communities by viewing them in a context of geologic, geomorphic and hydrologic variables. This integrated concept of RRH is the unit on which we focus to evaluate nps management.

Notice that while RRH denotes similar natural or achievable state (i.e. similar potential), riverine and riparian types denote similar existing state (i.e. similar condition). Comparisons within the same class of RRH, but different use, can be used to evaluate management and assess condition.

2.0 SCOPE

The purpose of this study was to develop methods to assess the effectiveness of management in protecting and enhancing RRH. The approach is not intended to predict the effects of a particular management activity, but to suggest an approach for assessing the accuracy of such predictions. To accomplish this, a classification that identifies RRH of similar potential was first developed. Assessments entailed comparing the existing states within a RRH to its potential or achievable state.

2.1 Approach

The distribution of stream and riparian habitat along the elevational gradients of watersheds corresponds with changes in climate, geology, geomorphology, hydrology and soils. The apparent relationships have led to hypotheses that RRH is a response to the climate and landscape in which it occurs, while others argue that the landscapes are an evolutionary response to the streams that they contain. This approach assumes that both RRH and their landscapes are a **coevolutionary** response to the same processes.

The most apparent mechanisms linking RRH and their landscapes are functional: the flow of water, sediment and energy. Precipitation and evaporation dictate the input to watersheds, thus influencing streamflow and groundwater. Tectonism determines the gradient of runoff while weathering produces sediment. Glacial, fluvial, alluvial and lacustrine mechanisms of sediment transport each result in distinctive types of RRH. In turn, the biotic component of RRH influences the physical processes, altering the flux of water and sediments. For example, riparian vegetation stabilizes streambanks, maintains the shape of stream channels and enhances retention of water in streambanks. This approach to classification and assessment is founded upon these functional relationships. A discussion of the major processes influencing RRH is contained in APPENDIX N.

This study focusses on the impacts of livestock grazing, which the authors regard as both extensive and profound. Other kinds of impacts (e.g. logging, roads, recreation, and crop agriculture) may affect RRH through similar or different mechanisms. While grazing may affect channel structure and stream stability, logging may affect pool quality and substrate embeddedness. While the approach for evaluating grazing and logging will be similar, criteria for assessment must be tailored to fit the mechanisms of impact.

The approach to classification and assessment in the pilot watershed followed these steps:

1. Classification to identify RRH of similar potential using a top-down hierarchy (broad scale to precise scale); at the most precise level of hierarchy, riverine and riparian types of similar existing state (condition) were identified.

2. Maps and tabular summaries of the dimensions (e.g. area) and attributes (e.g. slope) of RRH in the pilot watershed were prepared.

3. Maps and tabular summaries of the dimensions and attributes of riverine and riparian types in portions of the pilot watershed were prepared.

4. Attributes sensitive to livestock grazing were identified and measured in survey stations selected to include various states, ranging from near-natural to impacted.

5. Statistical analyses of attributes were used to assess condition relative to the potential for the RRH.

A regional perspective of the study area is discussed in the geographical overview, followed by a more detailed description of the pilot watershed.

2.2 Geographical Overview

The study area is in the Great Basin, a term first used by John C. Fremont. Contrary to its singular connotation, the region includes over 75 elongate basins, most lacking external drainage. The term has since been used to denote physiographic, hydrographic and floristic regions, each with somewhat different boundaries, all conforming, more or less, to the Northern Basin and Range Ecoregion (Omernik 1987). This geographical overview places the ecoregion in context with existing land classifications.

The ecoregion is included in the Great Basin Section (see Figure 2.2-1) of the Basin and Range Physiographic Province (Fenneman 1931; Hunt 1974), which is characterized by numerous north-to-south trending ranges separated by broad basins. The topography is the result of block faulting and the accompanying deposition of mineral debris (see Figure 2.2-2). An idealized progression of fault block ranges is illustrated in Figure 2.2-3. An east-to-west cross-section through the center of the Great Basin resembles a broad, partly collapsed arch (Morrison 1965) having its highest part in eastern Nevada and dipping towards both the east and west. The longitudinal profile dips to the south. Dutton (1880) likened the pattern of discontinuous, subparallel ranges to that of an "army of caterpillars marching to Mexico."

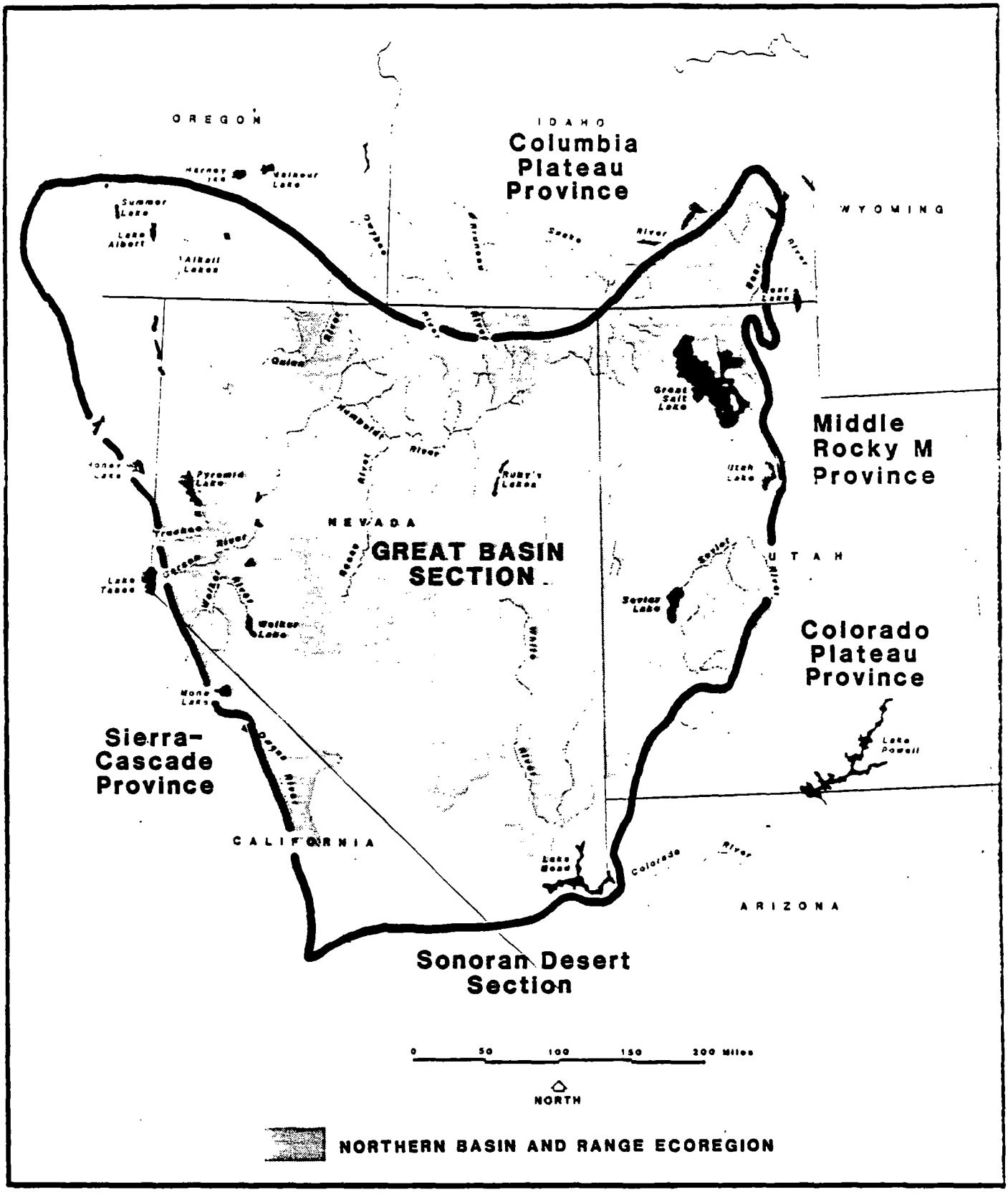


Figure 2.2-1. **Great Basin Section of the Basin and Range Physiographic Province (Fenneman 1931).**

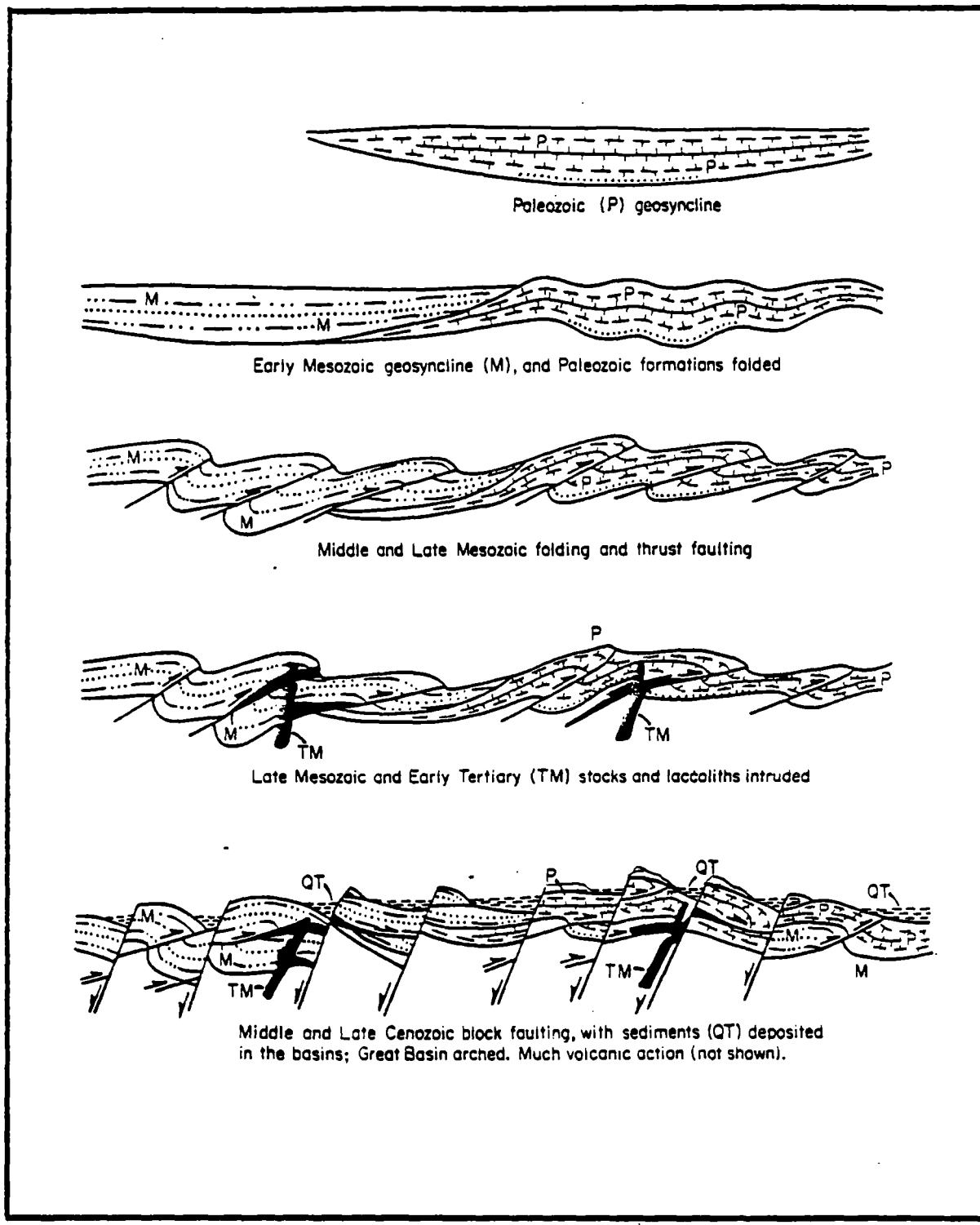


Figure 2.2-2. Evolution of geologic structure of the Great Basin (Hunt 1974).

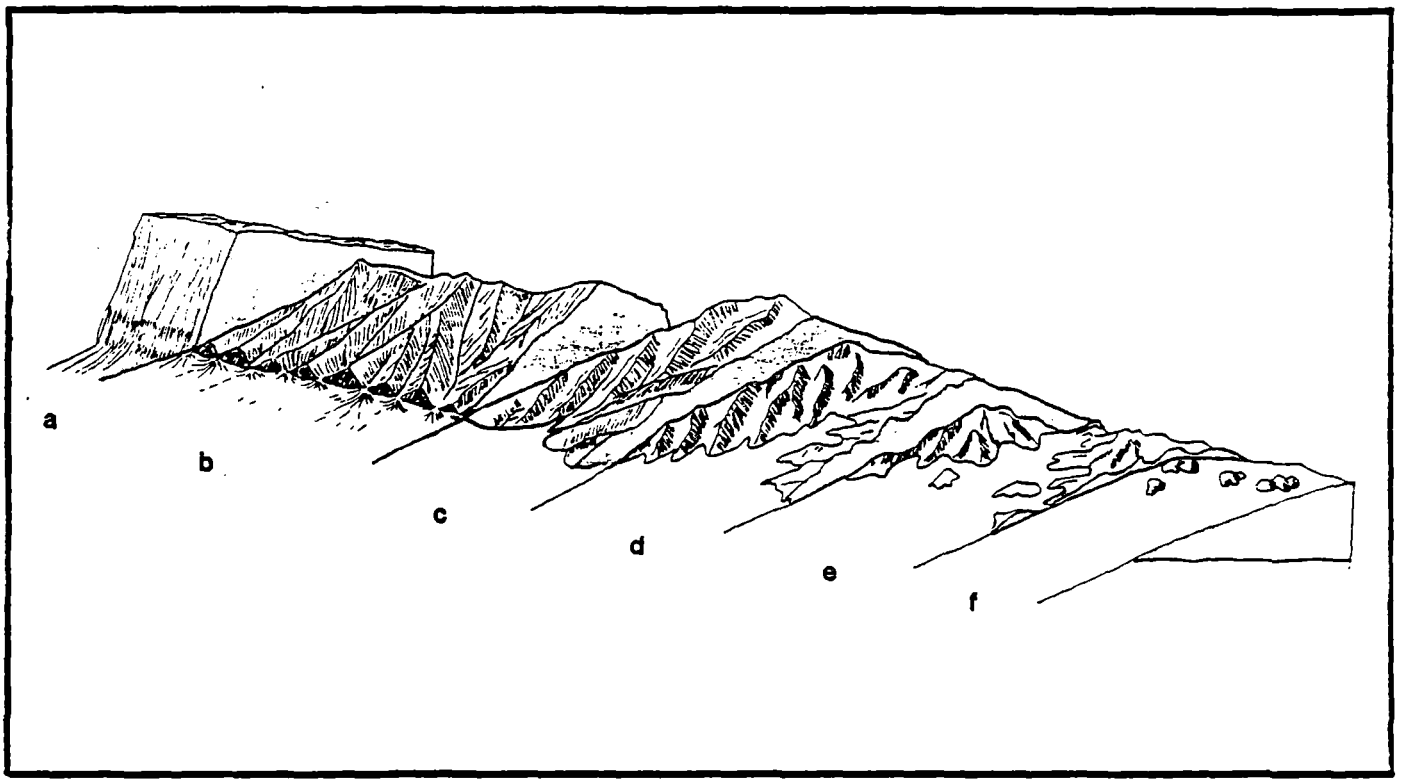


Figure 2.2-3. Geomorphic evolution of fault block landscape (modified from Fenneman 1931).

Hunt (1974) separated the Great Basin Section into five **subdivisions** based on structure, topography, hydrography and surface deposits (see Figure 2.2-4). The study area is within the Central Subdivision of the Great Basin Physiographic Section, which is topographically and structurally higher than the surrounding subdivisions (Morrison 1965). During the Pleistocene, at least 21 pluvial lakes formed in the Central Basins (Meinzer 1922). Dry lake beds and playas comprise about 10 percent of the Central Subdivision while mountains and alluvial landscapes each comprise about 45 percent of the area (Hunt 1974).

The Great Basin Hydrographic Region (see Figure 2.2-5) lacks external drainage. It includes most of the Northern Basin and Range Ecoregion, and portions of the Sierra Nevada, Snake River Basin, and the Wasatch Mountain Ecoregions. The hydrographic region can be further partitioned into: **subregions** including watersheds of similar hydrographic character; **basins** denoting watersheds with a common sink; and **subbasins**, differentiating major drainages contributing to a single sink. The target watershed (see Figure 2.2-6) is part of the NFH subbasin of the Humboldt River Basin of the Lahontan Basins Subregion, named for the Pleistocene lake that covered about 8,500 square miles (about the size of Lake Erie) to a depth of 856 feet (Hubbs et al. 1974). About 11,000 years ago the climate became warm and dry and only Pyramid and Walker Lakes remain (Gerstung 1982). Hydrographic delineations are useful for organizing geographical information, although their value for assessing ecological potential is questionable (Hughes et al. 1987).

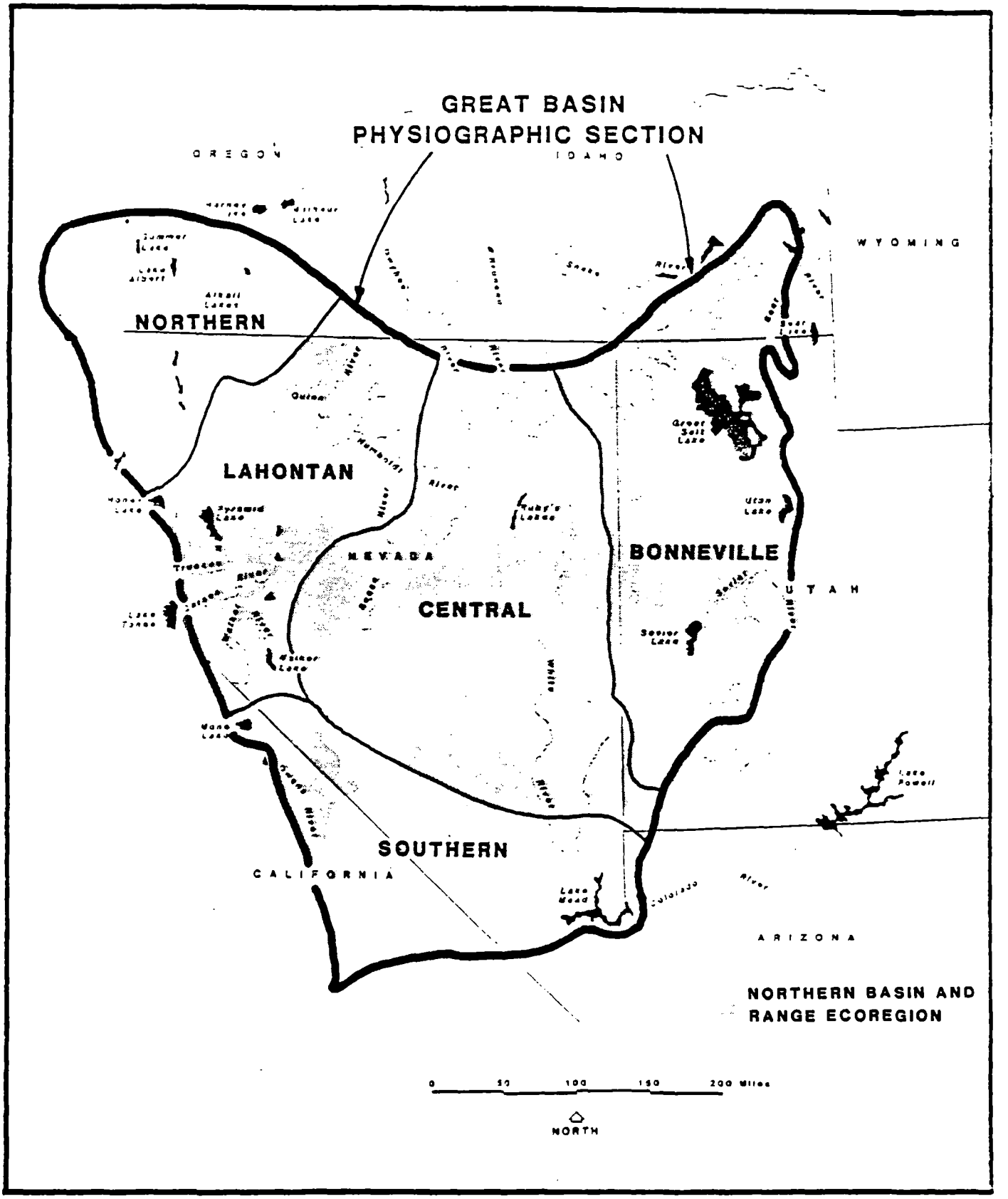


Figure 2.2-4. **Subsections of the Great Basin Physiographic Section (Hunt 1974).**

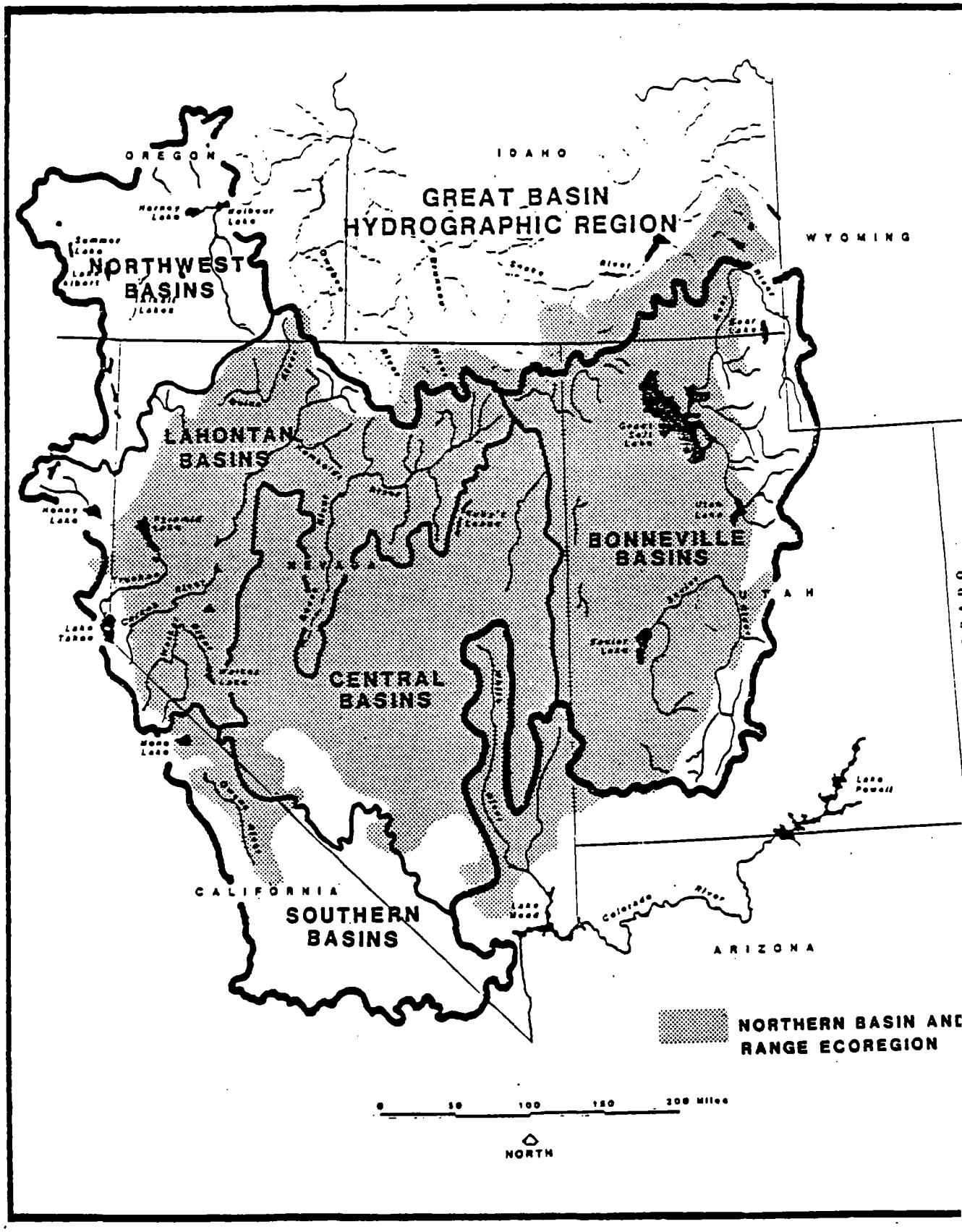


Figure 2.2-5. Subregions of the Great Basin Hydrographic Region.

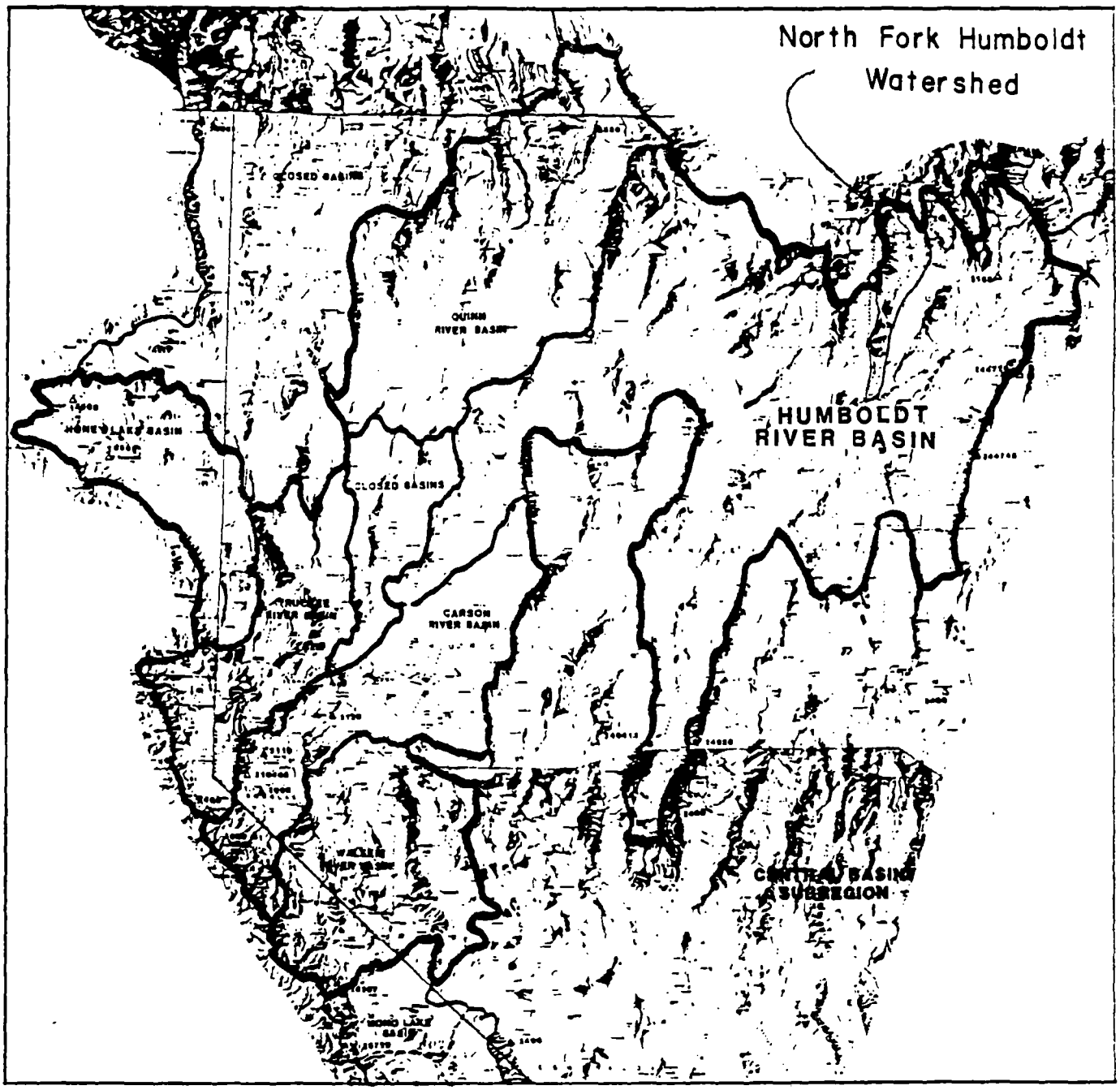


Figure 2.2-6. Hydrographic units of the Lahontan Basins Subregion.

The Great Basin Floristic Division (Cronquist et al. 1977) includes most of the Northern Basin and Range Ecoregion in addition to the Snake River Basin/High Desert Ecoregion of southern Idaho and Oregon (see Figure 2.2-7). It is divided into **sections** of more specific potential. The target watershed is within the Central Great Basin Floristic Section (ibid.). Kuchler (1964) identified Great Basin sagebrush (*Artemisia*), Wheatgrass-bluegrass (*Agropyron-Poa*) and Juniper Steppe Woodland (*Juniperus-Artemisia-Agropyron*) as potential natural vegetation types in the vicinity of the target watershed.

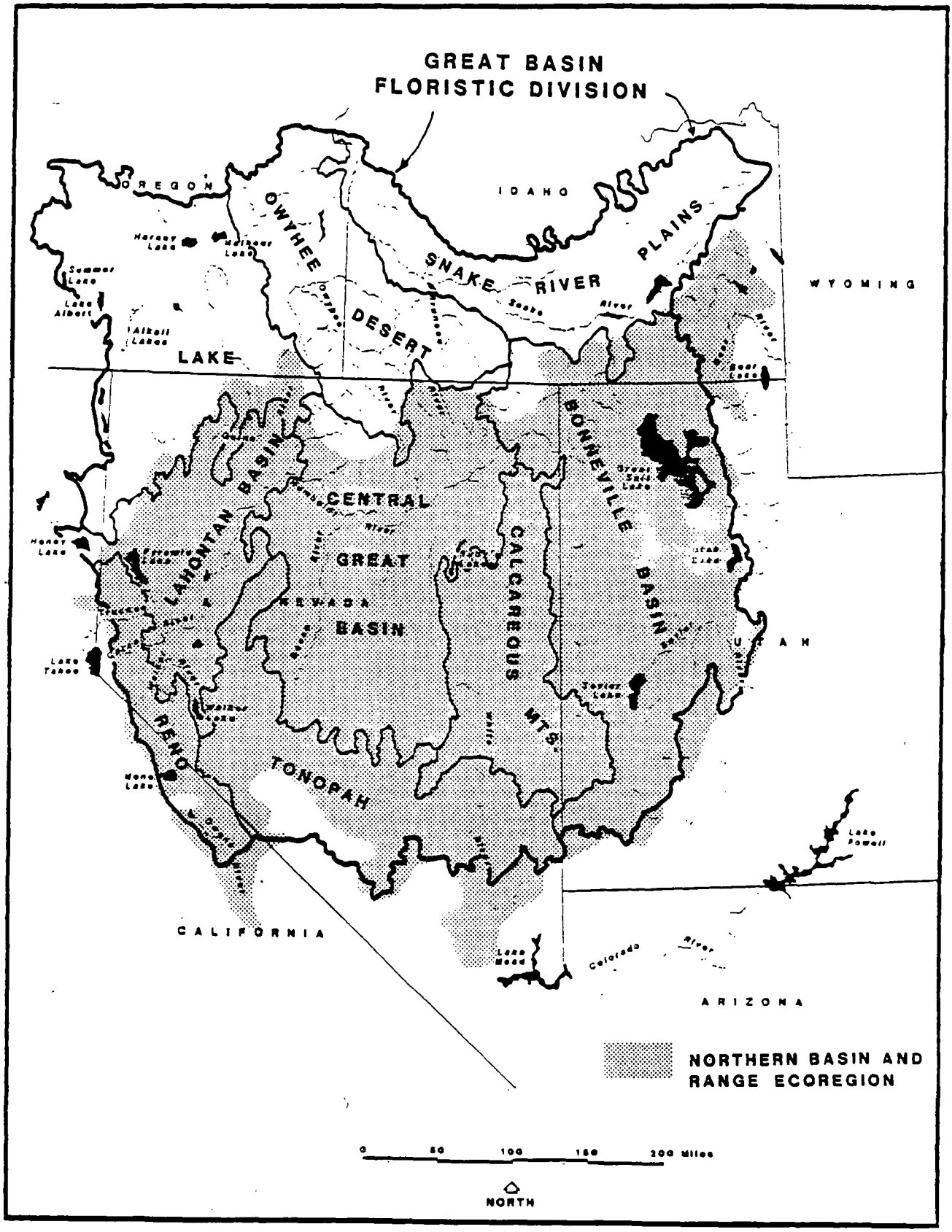


Figure 2.2-7. Sections of the Great Basin Floristic Division (Cronquist et al. 1972).

2.3 PILOT WATERSHED

Draining to the North Fork Humboldt River above Beaver Creek (see Figure 2.3-1), the target watershed is about 597 square miles. Elevations range from about 10,500 feet in the Independence Mountains to about 5,580 feet at the confluence of Beaver Creek. At Beaver Creek, the NFH is an Order 6 stream.

Northern Nevada is semiarid with average annual temperature at Elko, Nevada (elevation 5,085 feet) of about 34^{o} F and mean annual precipitation of about 9 inches, much of which falls as snow (NOAA 1986). Precipitation increases with elevation and may exceed 20 inches along the crest of the Independence Mountains. Potential evapotranspiration exceeds precipitation by several fold.

The watershed contains about 1,658 miles of stream. About 236 miles (14 percent) of the total stream length is perennial (on USGS quads). Stream attributes are summarized in Table 2.3-1.

Table 2.3-1. Stream attributes, North Fork Humboldt study area[1].

STREAM ORDER	---PERENNIAL STREAMS---			--INTERMITTENT STREAMS--		
	N	LENGTH (miles)	AVG GRADE (%)	N	LENGTH (miles)	AVG GRADE (%)
1	90	43.6	12.7	1556	901.9	5.2
2	111	43.5	6.5	602	299.8	2.6
3	166	59.5	2.2	240	121.5	1.6
4	112	35.9	1.4	61	23.1	0.9
5	91	41.1	0.3	31	15.1	0.3
6	15	11.2	0.2	0	0	0
TOTAL	**585**	**234.8**	**4.4**	**2490**	**1361.4**	**4.2**

(1) data from 1:24,000 scale USGS quads; upstream and downstream elevations of stream reaches were extrapolated from 20 and 40 foot contours.

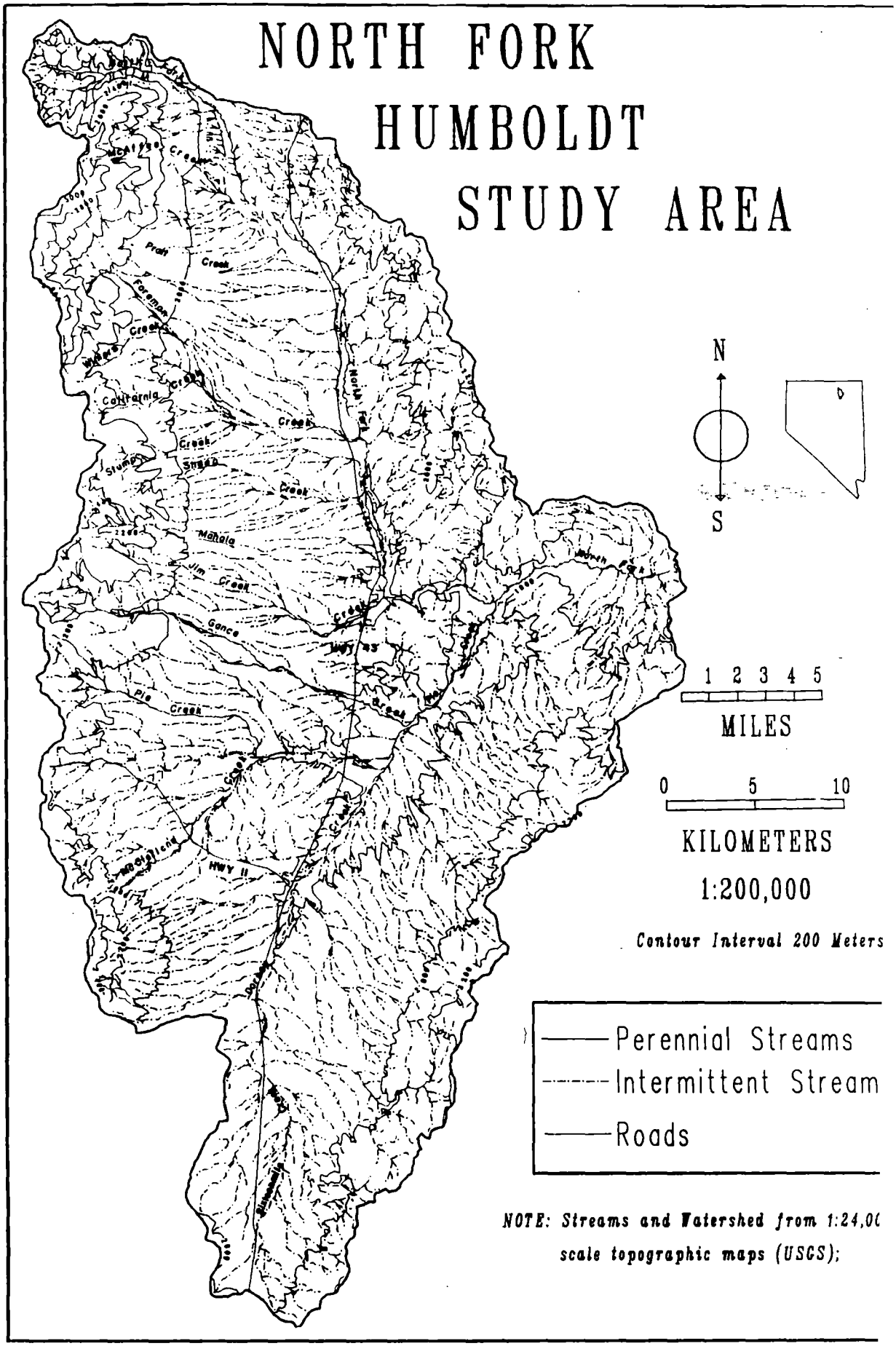

NORTH FORK
HUMBOLDT
STUDY AREA
N
S
1 2 3 4 5
MILES
0 5 10
KILOMETERS
1:200,000
Contour Interval 200 Meters
Perennial Streams
Intermittent Stream
Roads
NOTE: Streams and Watershed from 1:24,0
scale topographic maps (USGS);
Prah Creek
Foreman Creek
Contrarie Creek
Stump Creek
Mahala Creek
Jim Creek
Gance Creek
Pie Creek
HWY 11
HWY 93
North Fork

Figure 2.3-1

Two stream gauging stations are monitored by the USGS. The **North Fork Station** is located along the upper NFH River (see Figure 2.3-1) with a watershed of 12.1 square miles. Mean annual discharge is about 9.6 cfs although measured discharge has varied from 0 to 152 cfs; average annual discharge is about 6,980 acre-feet. The **Devils Gate Station** is located about 19 miles up from the confluence with the Humboldt River, with a watershed of about 830 square miles; average discharge is about 71 cfs, but varies from about 1 to over 10,000 cfs; average annual discharge is about 51,290 acre-feet. During the irrigation season, withdrawals deplete streamflow.

Lands are managed by the U.S. Forest Service, Bureau of Land Management and private owners (see Figure 2.3-2 and Table 2.3-2). Public lands are managed for livestock grazing, mining, and fish and wildlife habitat. Private lands are used mostly for pasture and native hay. While livestock ranching has long been the mainstay of the local economy, recent strip mining along the crest of the Independence Range has produced a new economic base, which has prompted a reevaluation of management policies and also has raised concerns about cumulative nps impacts.

Table 2.3-2. Ownership status, North Fork Humboldt study area.

OWNERSHIP	AREA (mi^2)	AREA (%)	STREAM LENGTH PERENNIAL (mi)	STREAM LENGTH PERENNIAL (%)	STREAM LENGTH INTERMITTENT (mi)	STREAM LENGTH INTERMITTENT (%)
Forest Service	72.4	12.1	56.7	24.1	85.5	6.3
BLM	329.8	55.3	46.6	19.8	798.1	58.6
Private	194.7	32.6	131.5	56.0	477.8	35.1
TOTAL	**596.9**	**100.0**	**234.8**	**100.0**	**1361.4**	**100.0**

The Humboldt race of the Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*), which is indigenous to the target watershed, is listed as threatened by the U.S. Fish and Wildlife Service, giving it protection under the Endangered Species Act of 1973. The Humboldt cutthroat, a race adapted to streams with extreme variations in water temperature, is endemic to the Humboldt River drainage (Coffin 1982; Platts and Nelson 1983). Coffin (1982) suggested that the best protection for the Humboldt race could be through better management of the NFH watershed, which has deteriorated in response to livestock grazing, roads, mining and agriculture.

Don't need protection?

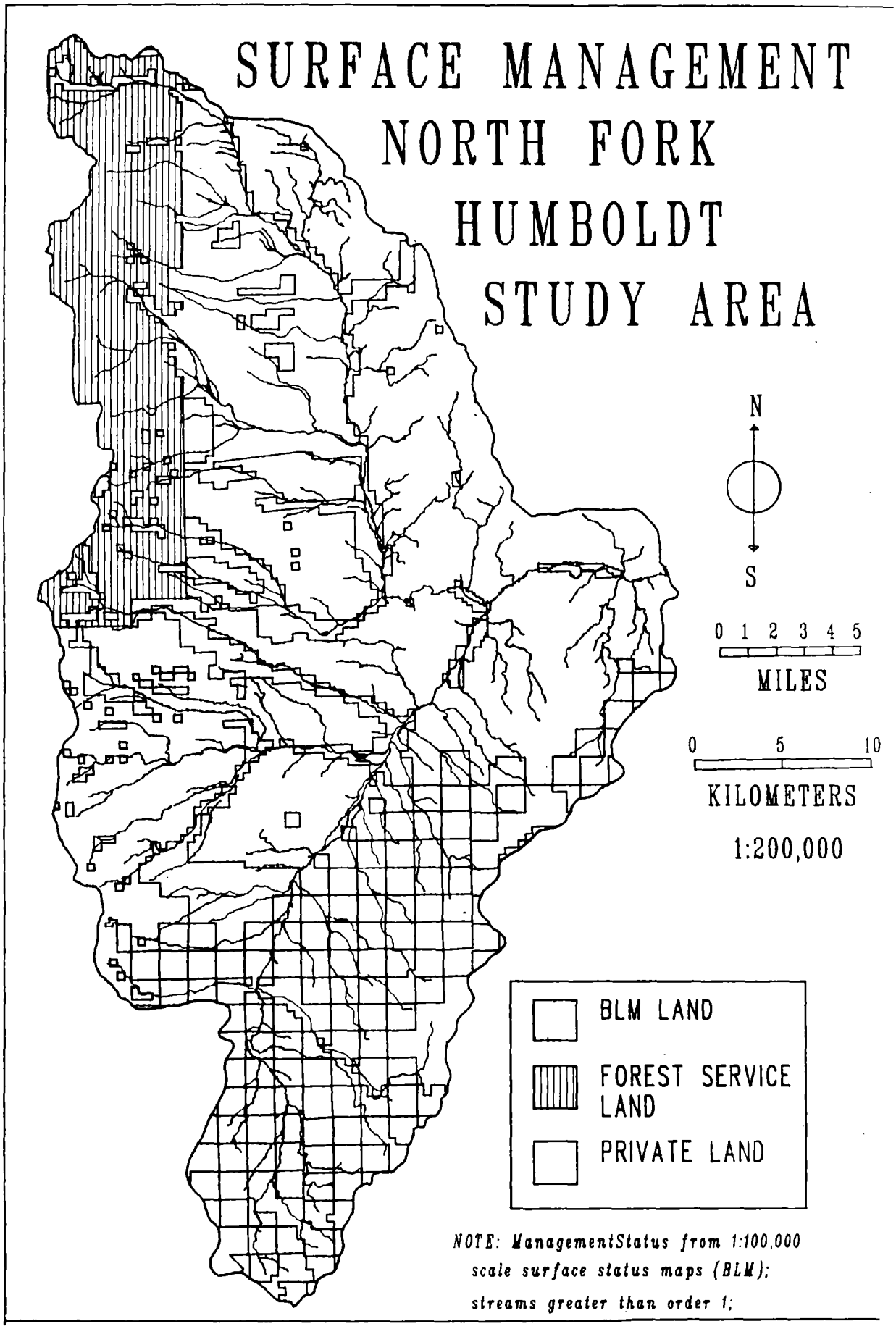

SURFACE MANAGEMENT
NORTH FORK
HUMBOLDT
STUDY AREA
N
S
0 1 2 3 4 5
MILES
0 5 10
KILOMETERS
1:200,000
BLM LAND
FOREST SERVICE LAND
PRIVATE LAND
NOTE: ManagementStatus from 1:100,000 scale surface status maps (BLM); streams greater than order 1;

Figure 2.3-2

3.0 METHODS

A hierarchical classification was used to identify RRH of similar potential and to identify landforms and vegetation types of similar existing state. Computer-generated maps and tabular summaries were prepared using ARC-INFO, a geographical information system prepared by Environmental Systems Research Institute in Redlands, California. Stream, riparian and fishery attributes were measured in 110 survey stations. While most stations were impacted, some were in various stages of restoration and a few were near-natural. Cluster and discriminate analyses were used to identify states (i.e. condition) and to find which attributes were most sensitive for identifying "natural" versus "impacted" states. Methods are discussed below with respect to the steps listed in the Approach (section 2.1).

3.1 Hierarchical Classification

John Stewart Mill (1891) described classification as a method of arranging objects into groups, and these groups into orders, that lead to understanding both the objects and relationships between them. A hierarchical structure provides different scales of resolution: objects may be classified in large, general groups or small, precise ones. This classification identifies RRH of similar potential so that meaningful comparisons can be made between existing states at the scale most appropriate to management and problem solving.

The purpose of the classification was to identify RRH with similar potential or achievable states and, within a RRH, to identify landforms and vegetation types reflecting the existing state of the habitat. The process entailed delineation of progressively smaller, more homogeneous areas. These were displayed as maps with successively greater detail. Seven hierarchical levels were used in the classification:

Ecoregion
Geologic District
Landtype Association
Landtype
Valley-Bottom Type
Landform
Vegetation Type

The classification is applied from the top (or broadest) level down. Omernik's (1987) map of ecoregions was used to identify regional differences in land-surface form, potential natural vegetation, land use and soil. The target watershed, located in the Northern Basin and Range Ecoregion, was divided into **geologic districts** according to criteria available from geologic maps, supported by field observations. Geologic Districts were divided into broad areas of similar geomorphic character (**landtype associations**) based on interpretation of maps, aerial photos and field observations: mountain ranges were glacial or fluvial while broad valleys could include alluvial or lacustrine landtype associations. Within each landtype association, the **valley-bottom landtype**, where streams and riparian habitat are found, was delineated from topographic maps. The valley-bottom landtype within a landtype association were divided into **valley-bottom types** of more distinctive form and functional character. Ecoregions, geologic districts, landtype associations, landtypes and valley-bottom types do not change (into other types) in response to most management applications. They include RRH of similar potential or achievable state.

Valley-bottom types were further classified by landform and vegetation type, based on attributes reflecting their existing state. While some landforms, such as alluvial fans, are static features little affected by management, others are more susceptible to change. Poor management may result in streambank erosion, causing an increase in the area of stream channels at the expense of floodplains and levees. Upland plants may replace riparian vegetation on floodplains in response to incision of the stream channel and drainage of the alluvial aquifer. While the distribution and character of landforms and vegetation types may change over relatively short duration in response to land-use, the valley-bottom type in which they are contained evolve on a geologic time scale and is not changed by cultural practices. Landforms and vegetation types were identified from large-scale (e.g. 1:3,000) aerial photos.

A preliminary classification of vegetation types found in Livestock/ Fishery Study Areas (LFSAs) in northern Nevada (Platts et al. 1988b) was revised and expanded to cover types encountered in the target watershed. Vegetation, soil, hydrologic and environmental attributes were described for communities representing each type. Descriptions of vegetation types generally followed those developed for classification of riparian community types (Norton et al. 1981; Tuhy and Jensen 1982; Youngblood et al. 1985). Vegetation types were related to a preliminary riparian community-type classification for Forest Service land in Nevada (Padgett and Manning 1988).

Plant species were identified in typical communities for each vegetation type. Plant identification followed Cronquist et al. (1977) and Welsh et al. (1987). A field guide prepared by Brunsfeld and Johnson (1985) was very useful for identification of willows (Salix spp.). Nomenclature follows Welsh et al. (1987). Unknown species were collected for identification at the Intermountain Herbarium at Utah State University in Logan, Utah.

Willows were verified by Robert Dorn (Mountain West Environmental Services; Cheyenne, Wyoming). Plant species identified in the target watershed are listed in APPENDIX F.

Plant cover (by species) was estimated for each site described. Estimates were calibrated by measuring cover in 10 systematically placed 0.1 square meter microplots. Cluster analysis was performed on a reduced data matrix of cover estimates to evaluate the floristic similarity between described sites. The Bray-Curtis coefficient (Motyka et al. 1950) was used to calculate the similarity between plots. A CLUSTAR program (Marshal and Romesberg, 1977) was used to calculate the pairwise comparison between plots. Vegetated riparian types were named according to floristic attributes of overstory and understory strata. Non-vegetated types were named according to substrate.

A soil profile was described to a depth of at least three feet, or to a depth below the groundwater level if shallower than three feet at each description site. The locations of soil pits were chosen to reflect the central character of each community. Methods for profile description were those used by the Soil Conservation Service (USDA-SCS 1982). Definitions and abbreviations were adopted from "Definitions and Abbreviations for Soil Descriptions" (USDA-SCS 1979). Soils were classified according to criteria in Soil Taxonomy (USDA-SCS 1975). Soil descriptions were used to ascertain the hydrologic characteristics of vegetation types. Vegetation types were grouped by community physiognomy and water regime.

Community physiognomy was determined by the life form of the uppermost stratum of vegetation with an aerial cover of at least 30 percent (Cowardin et al. 1979). Nonvegetated areas (e.g. streambars) were named by substrate. Physiognomic classes in the target watershed were:

forested: the canopy of woody vegetation covers more than 30 percent of the ground surface and trees (with a single trunk and taller 30 feet) are dominant.

shrub: the canopy of woody vegetation covers more than 30 percent of the ground surface and shrubs (arising from multiple branches and shorter than 30 feet) are dominant.

herbaceous: forbs, grasses, moss and lichen cover more than 60 percent of the ground surface and herbaceous vegetation is dominant; woody vegetation provides less than 30 percent aerial cover.

Streambar: usually within the stream channel; vegetation cover is less than 60 percent; types are named according to the particle-size of the substrate (e.g. cobble bar, gravel bar, sand bar, silt bar,); streambars with more than 30 percent vegetation cover are **herbaceous streambars.**

Water regimes denote the duration and frequency of flooding, saturation of the ground surface, or groundwater levels that fluctuate at least partly within the rooting depth of vegetation. Water regimes amended from those used to classify wetland ecosystems (Cowardin et al. 1979)) are illustrated in Figure 3.1-1 and defined below.

permanently flooded: water covers the surface throughout the growing season; the depth of water is less than would restrict establishment of wetland vegetation.

semipermanently flooded: water covers the surface throughout most of the growing season.

saturated: the substrate is saturated to the surface for extended periods of the growing season but surface water is seldom present; commonly associated with springs and seeps.

seasonally flooded: the surface is flooded for extended periods during spring runoff of most years, but surfaces are dry by the end of most growing seasons; commonly associated with floodplains and levees.

intermittently flooded: the surface is frequently flooded for brief intervals due to minor fluctuations in stream discharge; flooding may occur infrequently during any period of the growing season; commonly associated with streambars.

subirrigated: the surface is seldom flooded but groundwater level is within the rooting depth of vegetation for some period of the growing season; commonly associated with floodplains left high and dry due to channel degradation (downcutting).

artificially flooded: the amount and duration of flooding is controlled through irrigation practices; common on floodplains and alluvial fans in private pastures and hay lands.

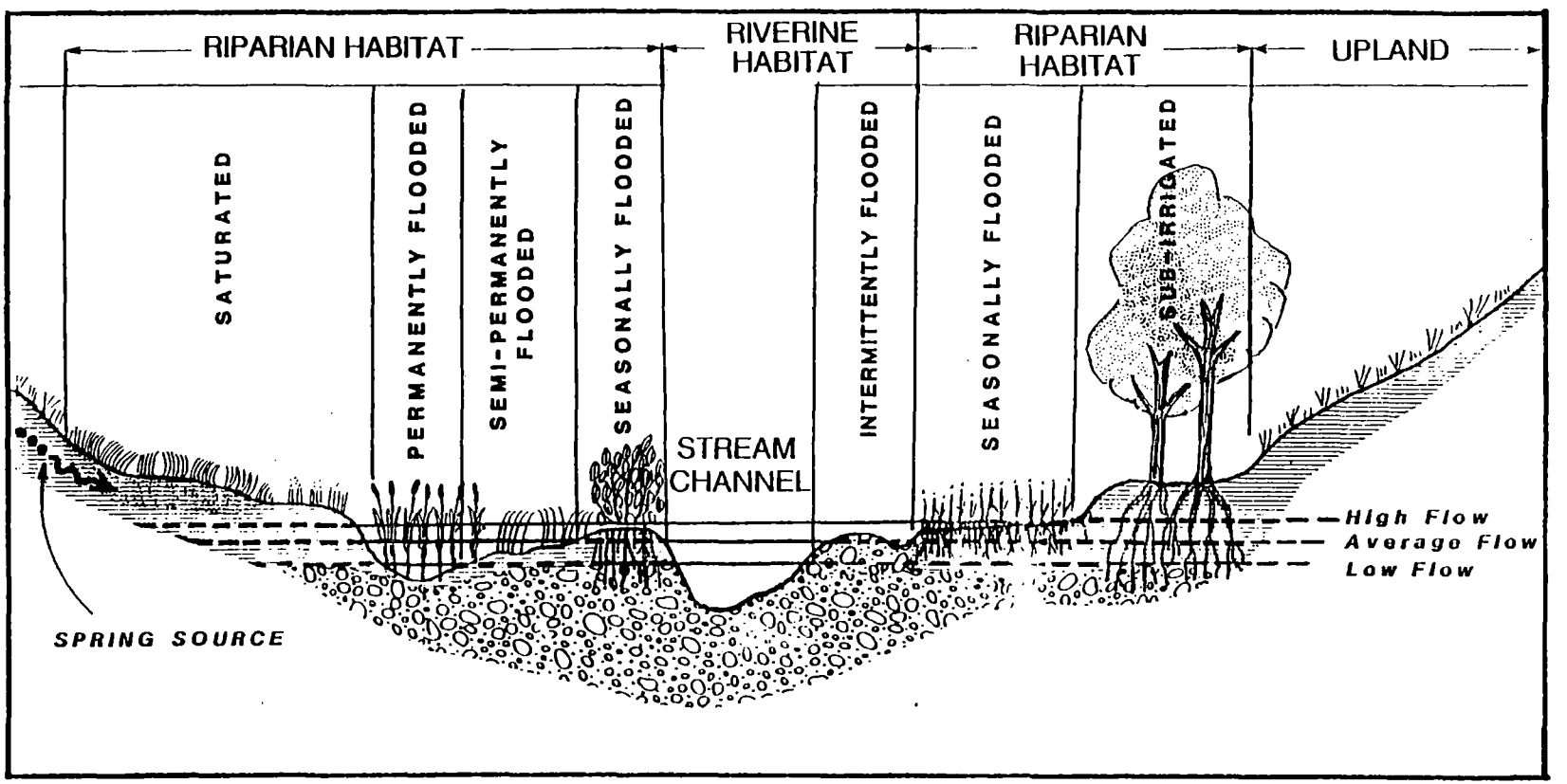


Figure 3.1-1. Water regimes.

Vegetation types were further grouped according to overriding hydrologic character and dominance in the landscape. These groupings are:

Aquatic types (AQTs): Permanently flooded aquatic habitat; perennial streams, lakes, ponds and impoundments; include vegetation types dominated by emergent plants.

Riparian types (RPTs): dominated by obligate and facultative hydrophytes, as specified in the Wetland Plant List for the Intermountain Region (U.S. Fish and Wildlife Service 1987); generally occur on levees and floodplains; vegetation types that were transitional from riparian to upland status were noted with a minus (-).

Riverine types (RVTs): Streambars and vertical aspects of streambanks, which may be vegetated to some degree; occur within the confines of the stream channel.

Upland types (UPTs): dominated by xeric vegetation; occur on alluvial fans, residual and colluvial slopes, and occasionally on floodplains and levees.

Miscellaneous types (MCTs): cultural features such as roads, ponds and mine-overburden, and infrequently encountered natural features such as boulders, talus and bedrock.

Hierarchical levels are further discussed in section 4.0 (CLASSIFICATION AND INVENTORY). Classes of ecoregion, geologic district, landtype association, landtype, valley-bottom type and landform are described in sections 4.1 through 4.6, respectively. A summary of vegetation types identified is presented in section 4.7; more detailed descriptions of vegetation types are included in APPENDIX M.

3.2 Inventory of Riverine/Riparian Habitat

Inventories of RRH with similar natural potential, functional characteristics and inherent values were prepared. They include maps and tabular summaries of the dimensions (e.g. length, area, perimeter) and attributes (e.g. gradient) of RRH in the pilot watershed. Inventories were assembled using ARC-INFO, a geographical information system. Each hierarchical level (e.g. geologic district, landtype association, etc.) was digitized as a separate map layer. A layer with stream courses was also prepared. Attri-

butes were assigned to discrete **polygons** (e.g. component rock types of geologic districts), **arcs** (e.g. order, flow status and gradient of streams) and **points** (e.g. codes for survey stations). Map layers were assembled and rectified to a common scale using Universal Transverse Mercator (UTM) coordinates.

Tabular summaries of the dimensions (e.g. area, length, perimeter) of combined map layers were generated. For example, geologic districts and rock types were overlaid to determine the area of component rock types (e.g. dolomite, limestone, etc.) within each geologic district; drainage densities were calculated from an overlay of geologic districts and stream courses; landtype associations and stream courses were overlaid to evaluate differences in stream gradient. A data base containing all map layers was generated. This **map data base** can be sorted by class (e.g. valley-bottom type) or any combination of attributes (e.g. stream order and flow regime).

3.3 Inventory of Landforms and Vegetation Types

Landforms and vegetation types were mapped for portions of four tributaries of the NFH River and for one stream draining the Snake Mountains about 40 miles east of the target watershed. These inventories include portions of two geologic districts, three landtype associations and six valley-bottom types. Landforms and vegetation types were identified from 1:2,000 to 1:4,500 scale color infrared (CIR) aerial photos. Preliminary maps were field-checked for three streams (Gance, Mahala and Tabor Creeks). CIR photos for two streams (Pratt Creek and North Fork) were not available until after the field season; these maps were compared with survey station data (see Section 3.4) and field notes.

3.4 Attributes of Riverine/Riparian Habitat

Stream, riparian and fishery attributes were measured in 110 survey stations between July and September, 1988; 71 survey stations were established in the target watershed (see Figure 3.4-1); 21 survey stations were established in the general vicinity (Elko County) of the target watershed; and 18 survey stations were established in northern Utah (Big Creek), northern Nevada (Mahogany Creek) and Southern Idaho (Wet and Trapper Creeks). The latter sites were geographically similar to the target watershed (see Figure 3.4-2). Stations were established in most geologic districts, landtype associations, and valley-bottom types identified in the target watershed and included a range of conditions, from near-natural to severely impacted.

Ideally, stations located in pristine watersheds unaffected by nps impacts were to serve as reference sites. Since no ideal reference stations were found, we selected small areas within watersheds that: 1) have received minimum on-site impacts from livestock; or 2) were historically impacted but which have since been rested or grazed under alternative management. The former type of reference station may serve as a potential endpoint of natural restoration while the latter may be indicative of some stage of natural restoration. While on-site impacts to these stations may have been successfully controlled, impacts originating off-site, such as headcutting, continue to influence them.

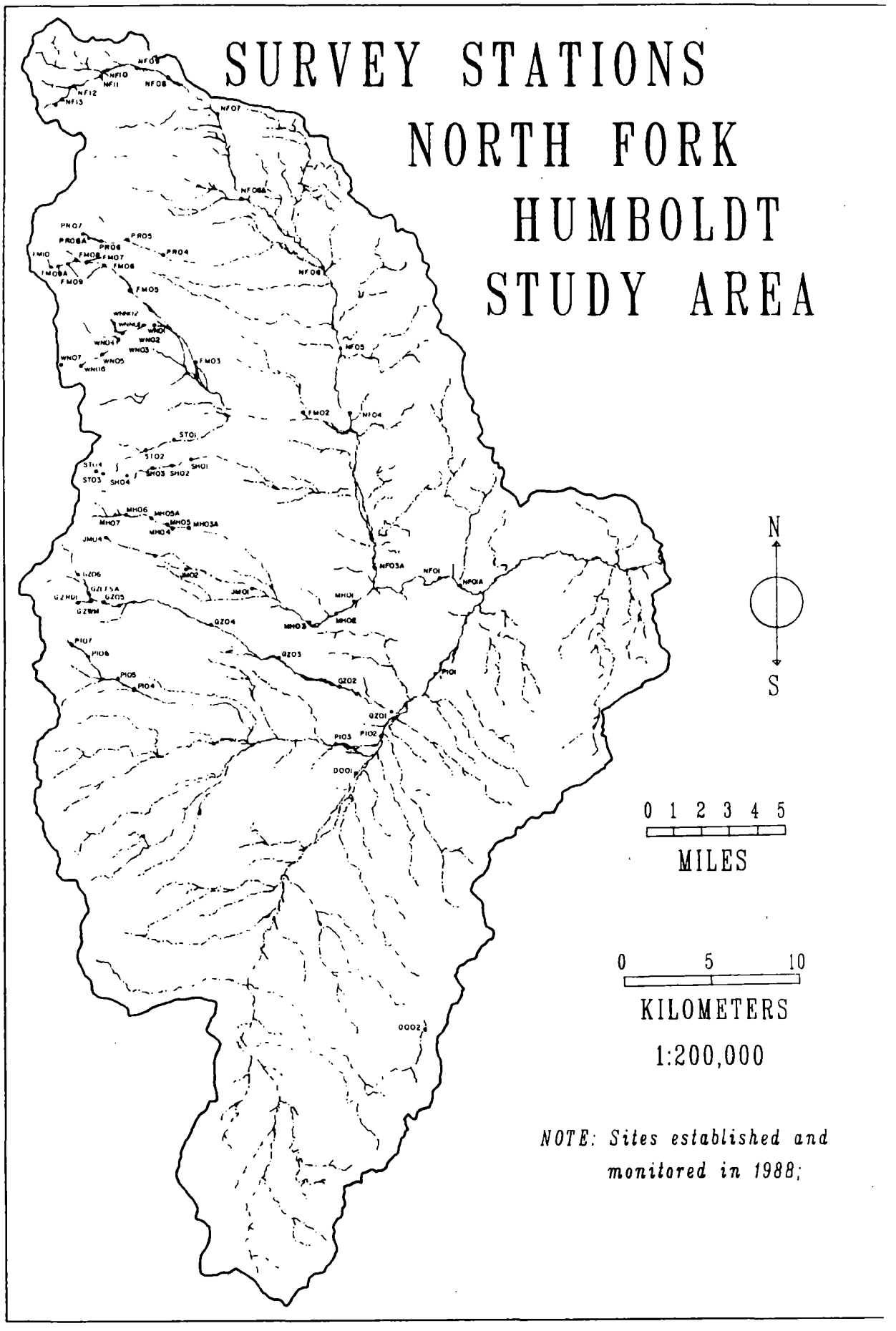

SURVEY STATIONS
NORTH FORK
HUMBOLDT
STUDY AREA
N
S
0 1 2 3 4 5
MILES
0 5 10
KILOMETERS
1:200,000
NOTE: Sites established and monitored in 1988;

Figure 3.4-1

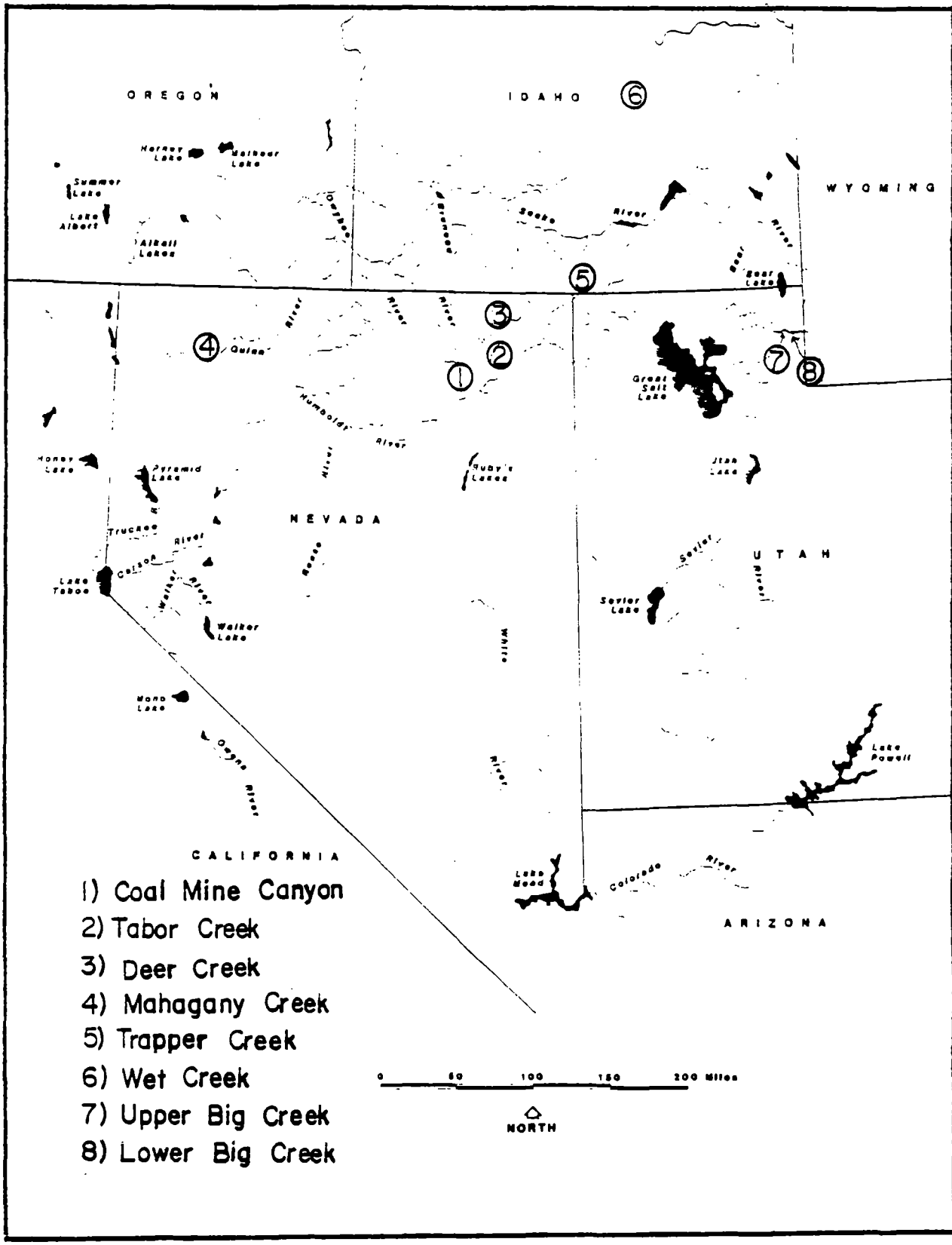


Figure 3.4-2. Survey stations outside the North Fork Humboldt study area.

Reference stations included: six livestock/fishery study areas (LFSAs) established under the direction of Dr. W.S. Platts (Gance, Tabor, Deer, Wet, Upper Big Creek, Lower Big Creek); two riparian exclosures in Coal Mine Basin that are managed by the Elko District BLM; a Forest Service pasture on Trapper Creek; and a watershed reserve (Mahogany Creek) managed by the Winnemucca District BLM. Treatment stations were impacted to some degree. They were selected to include different existing states for each class of RRH.

Each station consisted of twenty five transects perpendicular to streamflow, spaced at 30 foot intervals along the thalweg, and marked with stakes on either bank. Stream, channel and riparian attributes were measured along each transect. Attributes measured (listed below) were thought to be sensitive to nps impacts and important to the values (e.g. fishery) of RRH. Methods of measurement were developed by Platts et al. (1983, 1987).

Stream Attributes
- Bank water depth (0.1 feet)
- Stream width (feet)
- Stream depth at 25, 50 and 75 percent of stream width (0.1 feet)
- Maximum depth (0.1 feet)
- Riffle width (feet)
- Pool width (feet)
- Pool rating (class)
- Pool feature (class)
- Substrate classes (feet width)
- Substrate embeddedness (%)
- Instream vegetation (feet)

Channel Attributes (measured for left and right banks)
- Bank angle (measured $\pm$ 5 degrees)
- Bank undercut (0.1 feet)
- Bank stability (%)
- Width of streambars (feet)
- Width of eroded banks (feet)
- Depth of channel (feet)
- Width of channel (feet)
- Percent of banks with streambars
- Percent of banks eroded
- Bank conformation (class: concave, convex, straight)

Riparian Attributes (measured for left and right banks)
- Streamside vegetation use (%)
- Vegetation overhang (0.1 feet)
- Bank-forming vegetation type (class)
- Bank-forming landform (class)
- Minimum height of channel and bank-forming types above stream (feet)
- Maximum height of channel and bank-forming types above stream (feet)
- Width of landform and vegetation types occurring between the stream edge and 25 feet beyond the apparent streambank (feet)

Fish populations were measured at all survey stations in the target watershed where water was flowing and in Livestock/Fishery Study Areas (LFSAs); due to time and fiscal restraints, fish were not measured for ten survey stations outside the target watershed. Fish were stunned using a Smith-Root Model SR-VII electrofisher. Stream segments from 260 to 425 feet long were sampled. Block nets were placed upstream and downstream to prevent escape. The removal- depletion method (Platts et al. 1983) was employed. Successive removals were made until no fish were captured or until a removal pattern of 50 percent was achieved. Trout were measured to the nearest millimeter, weighed to the nearest gram and returned to the stream. Fish besides trout were simply counted. Actual populations were estimated using the maximum likelihood model (Armour et al. 1983; Platts et al. 1983). Data was processed using a MicroFish 3.0 software package (Van Deventer and Platts in press). The following parameters were generated: population estimate, mean weight, mean length, biomass and fish condition factor.

Stream discharge was measured near the lowest transect of each station. A Marsh-McBirney portable electronic current meter was used to measure velocity at a minimum of three points along the stream cross-section. Where depth was less than 0.7 feet, velocity was measured at 50 percent of the stream depth; for 0.7 to 2 feet depth, velocity was measured 60 percent depth; and for depths greater than 2 feet, velocity was measured at 20

percent and 60 percent depth.

Examples of field data sheets are included in APPENDIX A.

3.5 Synthesis and Interpretation

Classification and inventory were used to identify areas of similar potential. In these areas, stream, riparian and fish attributes measured along transects in survey stations were used to assess condition.

Statistical analyses were used to identify attributes sensitive to nps impacts. Cluster and discriminant analyses were used to determine the state for each transect. Condition ratings were then calculated as the average state of transects within a survey station. Condition ratings were related to a hypothetical progression of states, ranging from natural to severely impacted. In-depth discussions of these procedures are presented in section 5. Quality assurance/quality control procedures are discussed in APPENDIX K.

4.0 CLASSIFICATION AND INVENTORY

The classification is hierarchical and consists of seven levels (see Table 4.0-1). Classes of the top levels are based on regional criteria from small scale maps and general information sources. Classes of the lower levels are based on site-specific criteria from large scale maps and on quantitative information.

These hierarchical levels may be viewed as layers of information (see Figure 4.0-1). The top layers consist of large polygons (i.e. areas) that are described in terms of general criteria. At successively lower levels, these polygons are divided into smaller areas that are described in terms of more refined criteria, from which increasingly specific interpretations can be drawn. The classification is applied from the top level down, thus accounting for variance at the broadest level possible. The various scales used in the classification allow interpretation and generalization at perspectives ranging from regional to site specific. Site specific information for lower levels can also be integrated to support interpretations for higher levels.

Ecoregions (Omernik 1987) are the broadest level of classification. They are based on factors that cause regional variation in ecosystems or on factors that integrate the causes of regional variations. Principal factors used to identify ecoregions are land surface form, potential natural vegetation, land use and soils. Ecoregions have been used to identify streams of similar potential to facilitate impact assessments (Hughes et al. 1986; Rohm et al. 1987), for identifying streams with similar attainable water quality (Larsen et al. 1988) and for identifying streams with similar biotic and physiochemical characteristics (Hughes et al. 1987; Whittier et al. 1988).

Table 4.0-1. Hierarchical levels of classification.

Ecoregion	An area determined by similar land-surface form, potential natural vegetation, land-use and soil (Omernik 1987); they may contain few to many geologic districts.
Geologic District	A portion of an ecoregion with relatively homogeneous parent materials, distinguished from surrounding districts by structure, degree of weathering, dominant size-fractions of weathering products and water-handling characteristics (e.g. porosity, permeability, runoff potential); includes both uplands and bottomlands; it may contain one to several landtype associations.
Landtype Association	Some part (or all) of a geologic district that is distinguished by a dominant geomorphic mechanism (e.g. glacial, fluvial, alluvial, lacustrine); includes both uplands and bottomlands; it contains several landtypes.
Landtype	A portion of a landtype association distinguished by form and position; it corresponds with associations of soils and plant communities; RRH is contained within the **valley bottom landtype**, which may include few to several valley-bottom types.
Valley-Bottom Type	A subset of the valley-bottom landtype distinguished by form, structure and the manner in which water and sediment move through the system; they are generally distributed in a predictable manner along the elevational gradient of watersheds; it contains several to many landforms.
Landform	A portion of the valley-bottom type with distinctive morphology (e.g. channel, floodplain, levee, alluvial fan); although the same landform can occur in several classes of broader hierarchical categories, its attributes must be assessed in the context of the geologic district, landtype association and valley-bottom class in which it occurs; each landform may include one to several vegetation types.
Vegetation Type	A distinctive biological condition identified by physiognomic class (i.e. forested, shrub, herbaceous and substrate), water regime (e.g. seasonally flooded) and dominant plant species in overstory and understory canopies; it may change in response to land use.

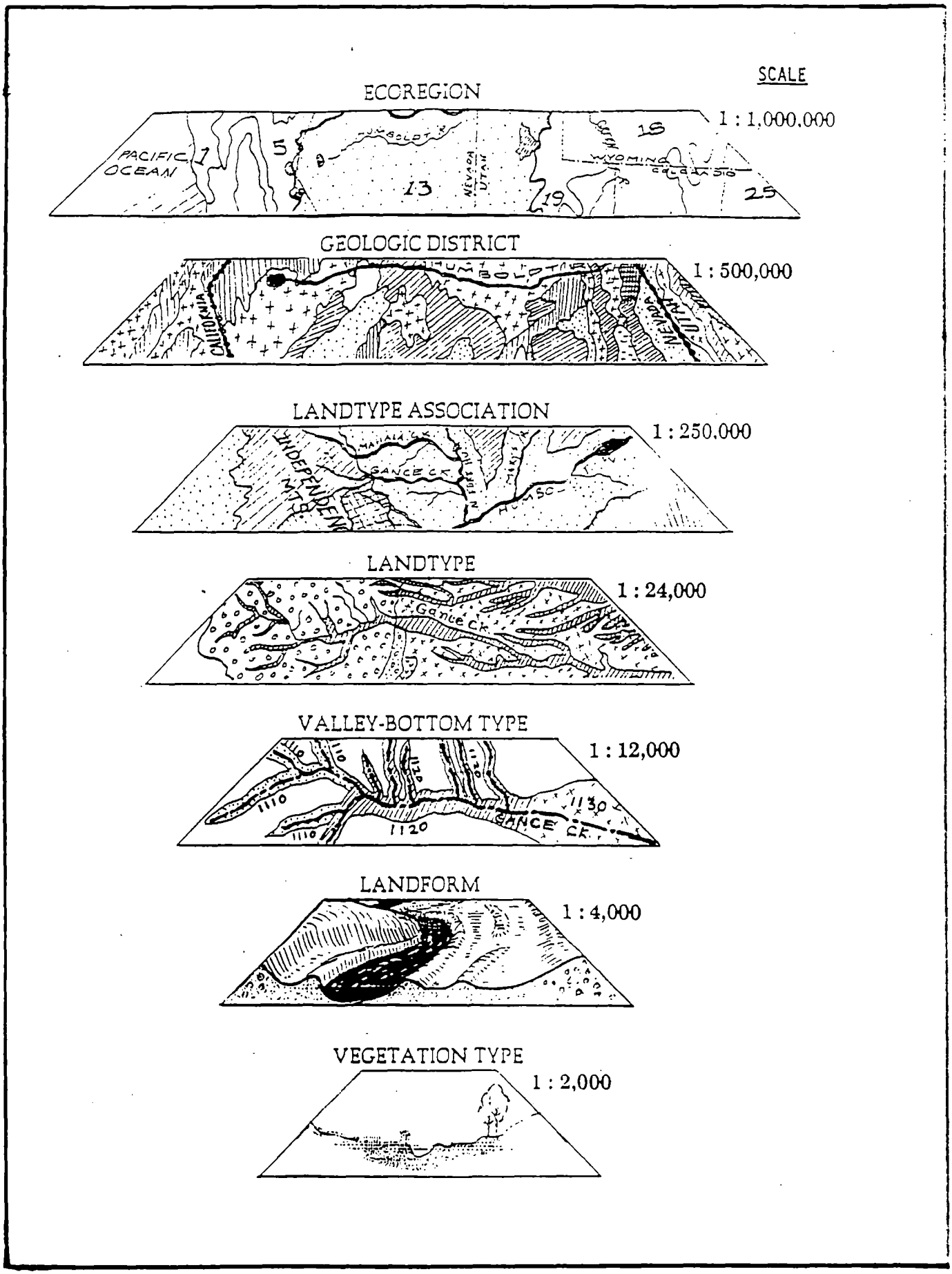


Figure 4.0-1. Map levels for hierarchical classification (not drawn to scale).

The diversity within ecoregions is not consistent. Some are similar throughout; others encompass great variation. The range in elevation and topographic diversity are relative measures of the diversity within an ecoregion. The scale at which the diversity is apparent also varies. In the High Desert/Snake River Plain, of rather flat lava, the variance occurs over large areas and can be shown on small (e.g. 1:1,000,000) scale maps. In the Northern Basin and Range Ecoregion, numerous high ranges separated by basins, the diversity occurs within comparatively small areas and must be indicated on larger (e.g. 1:500,000) scale maps. More inclusive analyses, at larger scales, are necessary to develop quantitative understanding of the variance within and between ecoregions (Omernik 1987).

Geologic districts are areas of similar rock types or parent materials that are generally associated with major structural features and areas of similar hydrographic character. Structural features (e.g. basalt flow, granite batholith, metamorphic block-fault range) are the templates on which streams have etched drainage patterns. In addition to directing runoff, they determine the location of springs, lakes and the courses of rivers. The hydrologic character of landscapes is also influenced by the degree to which parent material has been weathered (producing sediment) and the water-handling characteristics (e.g. porosity, retention, etc.) of the parent rock and its weathering products. The hydrologic character of hard rock (e.g. quartzite) that weathers slowly to mixed sizes (e.g. silt, sand, gravel and cobble) is different from that of soft rock (e.g. tuff) that weathers rapidly to fine-textured sediment. Geologic districts may be 10's to many 100's of square miles in size. They are correlary to subsections identified in U.S. Forest Service Land System Inventories (Wertz and Arnold 1972). Geologic districts do not change (to other types) in response to cultural practices. They include both uplands and bottomlands. Three geologic

districts were identified in the target watershed. They were mapped from geologic maps (Coats 1987), aerial reconnaissance and ground observations.

Landtype associations are identified by the dominant geomorphic processes responsible for shaping the landscape and influencing its functional character. Glacial, fluvial, alluvial and lacustrine processes have shaped landscapes and continue to influence the manner in which water and sediment move through ecosystems. These differences in form and function affect the potential of stream and riparian habitats and the responses to management applications. Landtype associations are subsets of geologic districts: glacial land in a granitic geologic district and glacial land in a metamorphic geologic district are classified as different landtype associations. Landtype associations have been identified for most Forest Service Regions as a component of the Land Systems Inventory (Wertz and Arnold 1972). They seldom change in response to cultural practices, include both uplands and the valley-bottom, and are 10's to 100's of square miles in size. Five landtype associations were identified in the target watershed. They were mapped from topographic maps and aerial photos, coupled with aerial and ground reconnaissance.

Landtypes are subsets of landtype associations that are identified by form and position in the landscape. They generally correlate with soil complexes, associations of potential vegetation and areas of similar hydrologic character (Wertz and Arnold 1972). Measures of discrete variables (e.g. runoff potential) for landtypes are common inputs for hydrologic and erosional modelling of watersheds. The vast majority of RRH occurs within a single landtype - **the valley-bottom landtype.** The character of the valley-bottom varies between different landtype associations. Landtypes seldom change (into other landtypes) in response to cultural practices other than

large-scale surface mining. Valley-bottom landtypes were mapped from aerial photos (1:14,560 and 1:24,000 scale).

Valley-bottom types are subsets of a valley-bottom landtype within a landtype association. They are distinguished by the mode or relative effectiveness of geomorphic processes in shaping the landscape and are usually distributed in a predictable manner. For example, the valley bottom landtype in the sedimentary geologic district and the glacial landtype association was divided into glacial basins (zone of erosion), glacial train (zone of transport) and glacial outwash (zone of deposition). Valley-bottom types seldom change (to another type) in response to cultural practices other than large scale surface mining. They denote areas of similar ecological potential. The twelve valley-bottom types identified in the target watershed were mapped from aerial photos (1:14,560 and 1:24,000 scale) paired with aerial and ground observations.

Landforms are components of a valley-bottom type. They are distinguished by form and position relative to environmental gradients. These criteria reflect the evolutionary character of landforms. Some landforms, such as channel, levee, floodplain and fan, occur in all valley-bottom types, although often in different proportions. Other landforms, such as moraine, occur only in glacial valley-bottom types. Viewed from a evolutionary perspective, landforms are areas of more distinctive potential within a valley-bottom type: where alluvial fans, moraines or residual slopes form streambanks, they are inherently less stable and more subject to erosion than streambanks formed by floodplains and levees. Viewed from the management perspective, landforms can be changed from one type into another: livestock grazing can cause erosion of streambanks, leading to an increase in the area of stream channels and decrease in the areas of floodplains and levees. Viewed in context with the stream and channel characteristics (e.g.

incised versus graded versus ponded) the potential natural communities of landforms can be ascertained. Landforms were mapped from large scale (1:3,000) aerial photos and verified by field inspection, leading to the most precise level of classification and inventory.

Vegetation types (in this study mostly riparian types) are the most precise map layer. They were identified by physiognomic class (i.e. forested, shrub, herbaceous and substrate), water regime (e.g. seasonally flooded) and dominant plant species in overstory and understory canopies. Vegetation types tend to correlate with landforms; shrubs are common on levees while floodplains are typically herbaceous. While the same vegetation types may occur in different valley-bottom types, their proportional areas and habitat characteristics tend to be different. Vegetation types in the target watershed (and throughout much of the West) have been altered by cultural impacts. Streamside vegetation has been replaced by streambars due to trampling by livestock. Livestock, roads, and agriculture have altered channel form, often resulting in a lowering of alluvial ground water and encroachment of upland vegetation onto floodplains. Vegetation types reflect the existing state of RRH. They were mapped from large-scale aerial photos coupled with a considerable degree of field verification.

Classifications of riparian community types are available for many areas in the West. Classification efforts have been conducted by the U.S. Forest Service for the Greys River drainage (Norton et al. 1981), the upper Salmon and Middle Fork Salmon Rivers, Idaho (Tuhy and Jensen 1982), the Big Piney Ranger District in western Wyoming (Mutz and Graham 1982), the Centennial Mountains and South Fork Salmon River (Mutz and Queiroz 1983), eastern Idaho and western Wyoming (Youngblood et al. 1985), southern Utah (Padgett and Youngblood 1986), and Nevada (Padgett and Manning 1988). Similar

studies have identified riparian dominance types of Montana (Hansen et al. 1987) and riparian zone associations in southeastern Oregon (Kovalchik 1987). Classifications of vegetation types were also prepared for livestock/fisheries study areas in Utah (Platts et al. 1988a) and Nevada (Platts et al. 1988b). Many classification efforts are ongoing and are expected to be available in the near future.

Criteria for identification of geologic districts, landtype associations, landtypes and valley-bottom types are little influenced by management. Lands in the same class with similar drainage area are expected to include RRH with similar **potential**. While landforms evolve in response to natural processes and improve estimates of potential within valley-bottom types, they also can be changed in response to land use and thus reflect an existing state or condition. Vegetation types readily change and are areas of distinctive **existing state** within a landform or valley-bottom type.

An application of the classification is illustrated in Figure 4.0-2. At the most refined level of classification, a *Poa pratensis* (POPR) community is identified. This community occurs on a floodplain in a V-shaped depositional valley-bottom type. It is part of the valley-bottom landtype, fluvial landtype association, sedimentary geologic district, and the Northern Basin and Range Ecoregion.

ECOREGION

Northern Basin and Range

GEOLOGIC DISTRICT

Sedimentary *Volcanic* *Tuffaceous*

LANDTYPE ASSOCIATION

Glacial ***Fluvial*** ***Alluvial***

LANDTYPE

Cirque *Slope* *Escarpment* *Hill* *Valley-bottom*

VALLEY-BOTTOM TYPE

Basin *Train* *Outwash* *V-shaped* *Notch-shaped* *Floodplain*

erosional *erosional* *confined*

depositional *depositional* *unconfined*

LANDFORM

Channel *Floodplain* *Levee* *Alluvial Fan* *Moraine* *Colluvial Slope* *Residual Slope*

VEGETATION TYPE

Forested	Shrub	Herbaceous	Substrate
POTR/MH	SALIX/MH	CANE	COBBLE BAR
ABLA/UP	ALIN/MF	POPR	GRAVEL BAR
POTR/UP	SALIX/CAN	HAY	SAND BAR
ETC.	ETC.	ETC.	ETC.

Figure 4.0-2. Exemplary application of the hierarchical classification.

A four digit code (e.g. 1220) was used to identify combinations of geologic district, landtype association and valley-bottom type (see Figure 4.0-3). The numbers denoting specific classes were generally ordered from highest elevation (or relief) down. Thus, the sedimentary geologic district, with the highest relief was coded 1000; glacial lands in this same district, occurring along watershed divides, was coded 1100; glacial basins, occuring in the heads of glacial lands were coded 1110. Codes for each class are listed with respect to descriptions of hierarchical levels.

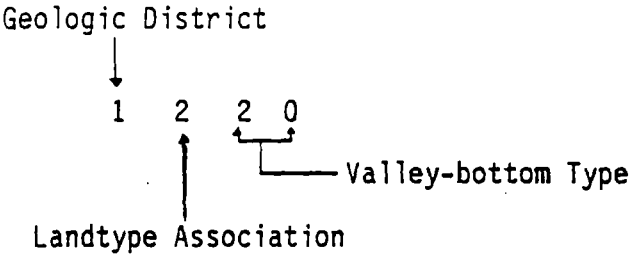


Figure 4.0-3. Conventions of coding system.

One vital point in using this system is that it is applied from the top (or broadest) level down. The character of more refined classes must be viewed in the context of the more general classes. Land managers are faced with making decisions at several levels of precision. While regional policy decisions will require assessments from broader perspectives, say at the level of geologic district or landtype association, the location of a road crossing or camp facility will require assessments of landforms and vegetation types at the most precise levels of classification. The hierarchical classification allows for interpretations and assessments at perspectives ranging from regional to site specific. Site specific information can also be ordered and evaluated in the framework of more general levels of classification; thus, refined interpretations can be used to support policy deci-

sions applied over broader regions.

Descriptions of the ecoregion, geologic districts, landtype associations, valley-bottom landtypes, valley-bottom types, landforms and vegetation types identified in the target watershed follow. Maps and tabular summaries of the areas of landforms and vegetation types are found in the Map Supplement document. Tabular summaries of stream, channel and riparian attributes measured in survey stations are included in the Pilot Study Appendices document.

4.1 Ecoregion

The target watershed is within the Northern Basin and Range Ecoregion (Omernik 1987) as shown in Figure 4.1-1. Typical areas are: plains bounded by mountains; Great Basin sagebrush, saltbrush/greasewood potential natural vegetation; desert shrublands grazed by livestock; and soils classified as Aridisols at the order level (Omernik and Gallant 1987). It lies in the rain shadow of the Sierra Nevada and is semi-arid to arid. Numerous lesser rain shadows result from the orientation of the mountain ranges across prevailing storm tracks. The target watershed is a transition to the Snake River Basin/High Desert Ecoregion to the north. Classification at lower levels was used to specify the sources of variance within ecoregions.

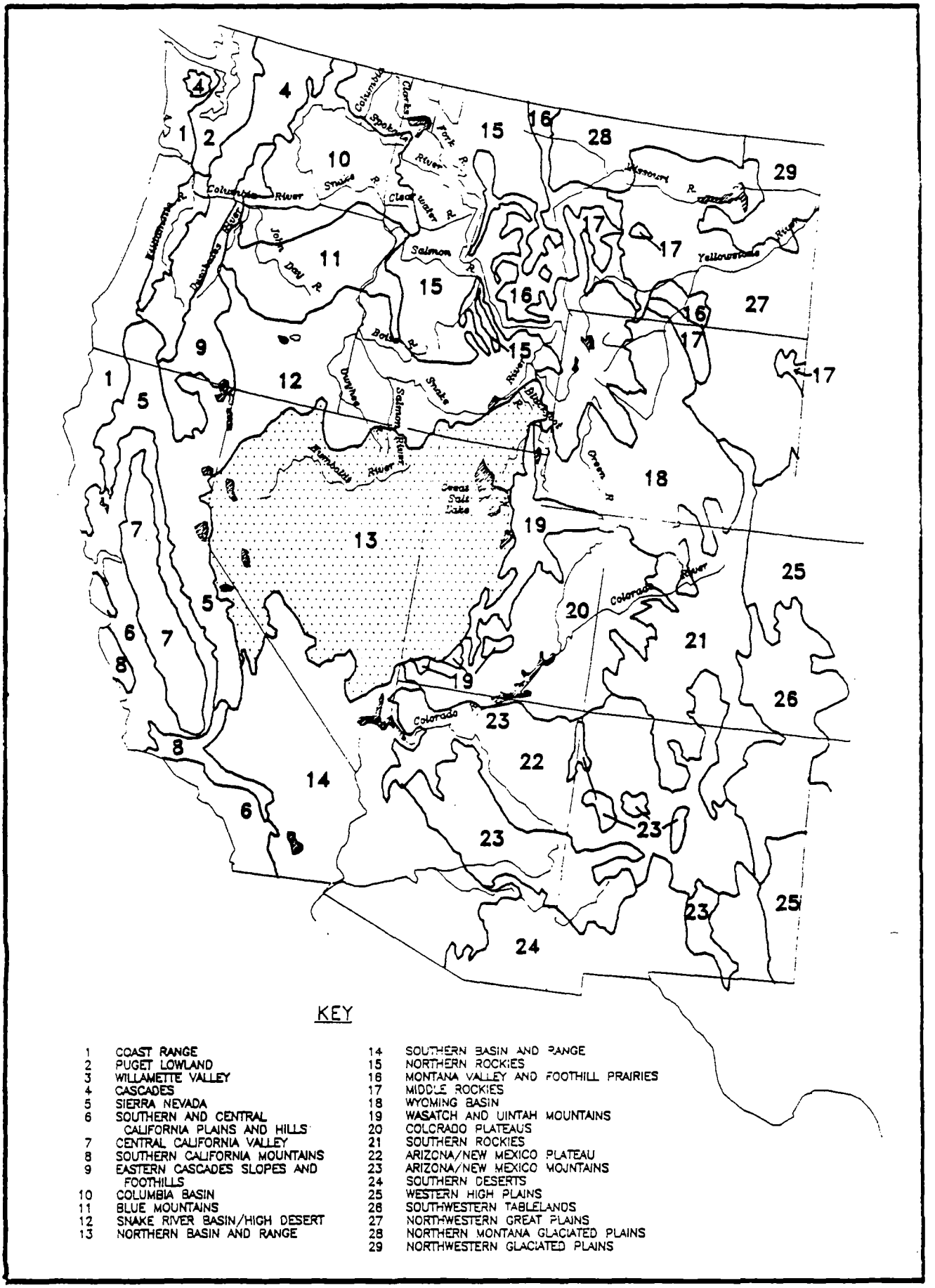


Figure 4.1-1. Ecoregions of the western United States (Omernik 1986).

4.2 Geologic Districts

Three geologic districts were identified in the target watershed. Descriptions were formulated from a 1:500,000 scale geologic map of Nevada compiled by Stewart and Carlson (1978) and a 1:250,000 scale geologic map of Elko County compiled by Coats (1987). Geologic districts identified in the target watershed are:

Sedimentary (1000): mostly siliceous sedimentary rocks of Mesozoic age; includes shale, siltstone, sandstone, chert, greenstone, conglomerate and limestone; small areas of Tertiary volcanic rocks are also included; forms areas of high relief along the flanks of the target watershed; weathers at a slow to moderate rate to a broad range of sediment sizes; similar assemblages of rock types recur in mountains of northeastern Nevada.

Volcanic (2000): rhyolitic flows and shallow intrusive rocks of Tertiary age; forms areas of moderate to high relief in the Adobe Range on the eastern flank of the target watershed and areas of low relief in the valley; appears to weather at a moderate rate, mostly to sand and cobble sediment sizes; forms extensive areas of northern Nevada that are transitions between the Northern Basin and Range and the Snake River/High Desert Ecoregions.

Tuffaceous (3000): includes welded and nonwelded ash-flow tuffs and tuffaceous sedimentary strata including tuff, vitric (glassy) ash, tuffaceous siltstone, conglomerate and limestone; quaternary alluvium is included along stream courses; appears to weather rapidly to a preponderance of fine-textured sediments; ash-flow tuffs occur on the southern portion of the Independence Range and on Double Mountain; tuffaceous sedimentary strata occur in association with alluvial deposits in lower positions of the NFH watershed; forms surfaces of moderate to low relief; recurs extensively throughout northeastern Nevada.

Geologic districts are illustrated in Figure 4.2-1 and delineated in Figure 4.2-2. The areas of geologic districts in the target watershed are listed in Table 4.2-1. The relative distribution of rock types in geologic districts are listed in Table 4.2-2. Each geologic district contains inclusions of rock types typical of other geologic districts. Stream attributes are summarized in Table 4.2-3.

A) Sedimentary (1000 GD), Independence Range.

B) Volcanic (2000 GD), Adobe Range.

C) Tuffaceous (3000 GD), North Fork basin.

Figure 4.2-1. Geologic districts, North Fork Humboldt study area.

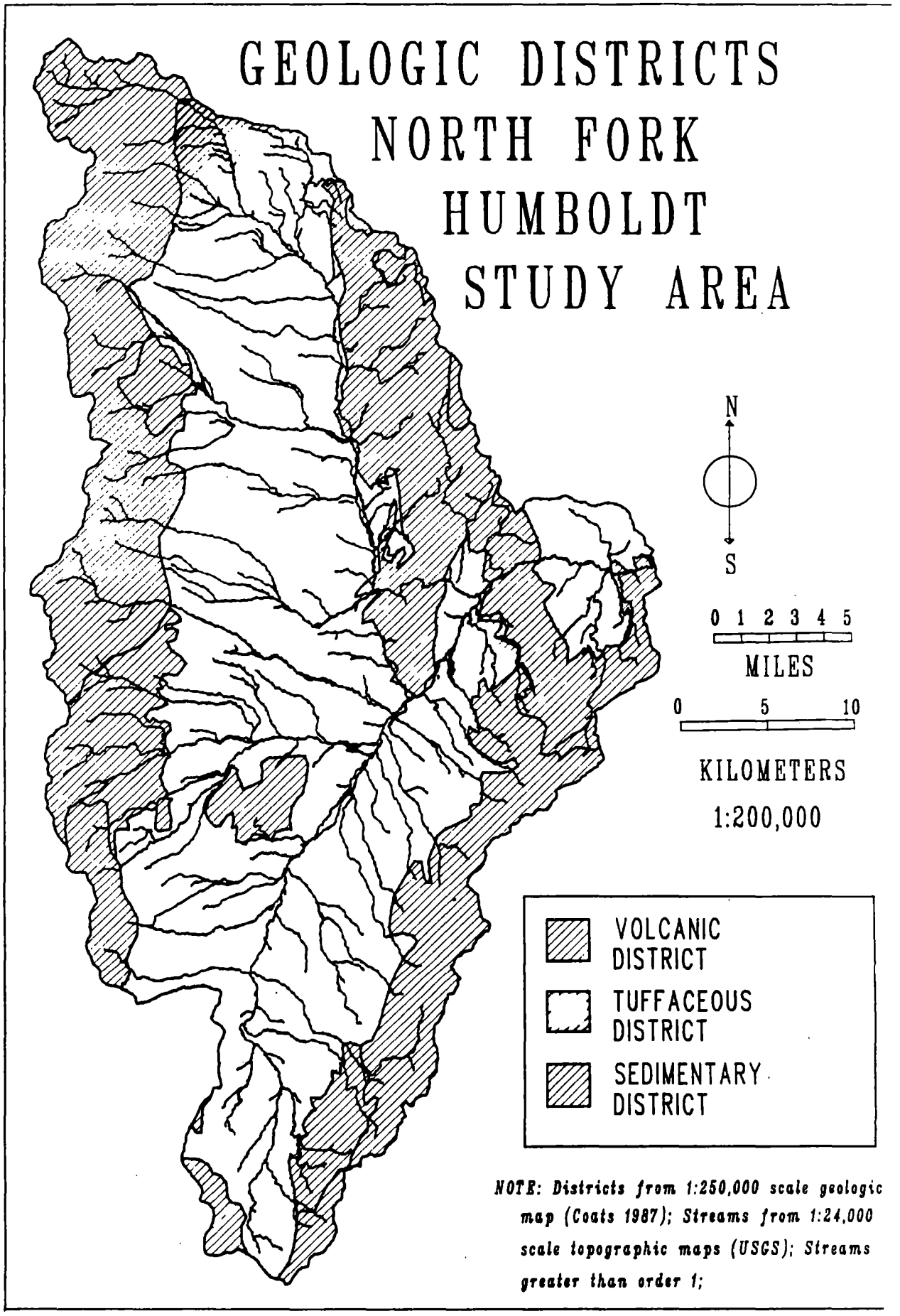

GEOLOGIC DISTRICTS
NORTH FORK
HUMBOLDT
STUDY AREA
N
S
0 1 2 3 4 5
MILES
0 5 10
KILOMETERS
1:200,000
VOLCANIC DISTRICT
TUFFACEOUS DISTRICT
SEDIMENTARY DISTRICT
NOTE: Districts from 1:250,000 scale geologic map (Coats 1987); Streams from 1:24,000 scale topographic maps (USGS); Streams greater than order 1;

Figure 4.2-2

Geomorphic classes are illustrated in Figure 4.3-1 and delineated in Figure 4.3-2. Landtype associations (see Figure 4.3-3) were identified by overlaying the map of geomorphic classes with the map of geologic districts. The boundaries of geomorphic classes and geologic districts were often congruent. Sliver polygons less than three square miles in size were combined by geomorphic class. Areas are summarized in Table 4.3-1.

Glacial lands comprise 8.5 percent of the target watershed, fluvial lands comprise 34 percent and alluvial lands comprise about 57.5 percent. Average stream attributes from USGS quads are listed in Table 4.3-2.

4.3 Landtype Associations

Landtype associations were based on the dominant geomorphic process responsible for shaping the landscape. A more-precise mapping of **geomorphic classes** within a geologic district was used to identify **landtype associations.** Three geomorphic classes were identified in the target watershed:

Glacial land: Glaciers formed along the crest of the Independence Mountains at elevations ranging from 8,500 to 10,500 feet and advanced down existing drainages to elevations of about 7,200 feet; outwash plains extend well beyond the maximum glacial extent; streams are relatively high gradient and substrates are mostly cobble; glacial land occurs in 17 interior ranges of the Great Basin Physiographic Section (Blackwelder 1934).

Fluvial land: mountainous areas dissected by stream erosion; elevations range from about 6,200 to 8,500 feet; characterized by V-shaped and notch-shaped valleys and moderate to high-gradient streams; channel substrates are variable; fluvial lands are dominant in mountains of the Northern Basin and Range Ecoregion.

Alluvial land: broad, structural valleys nestled between block fault ranges; the intermontane valleys have been filled to great depths with sediment weathered from adjacent mountains; elevations range from about 5,500 to 6,600 feet; includes areas of relatively low relief and low gradient streams with relatively fine substrate; alluvial land occurs extensively throughout the Northern Basin and Range Ecoregion.

Lacustrine basins are broad, nearly level areas of relatively fine-grained, often saline sediments at the termini of Great Basin streams. Where fed by perennial streams (common along the eastern and western flanks of the ecoregion) these basins support extensive wetlands and/or terminal lakes. Ephemeral streams draining ranges within the Great Basin terminate in playas. While lacustrine basins do not occur in the target watershed, they are extensive in the Bonneville Basins of western Utah and in the Lahontan Basins of western Nevada. Smaller lacustrine basins lie at the bottom of watersheds throughout the Northern Basin and Range Ecoregion.

Other geologic districts occur in the Northern Basin and Range Ecoregion. For example, granitic rock is common in the Ruby Mountains, about 50 miles southeast of the target watershed. RRH in the Ruby Mountains is more like that described in the Upper Salmon/Middle Fork Salmon Basin (Tuhy and Jensen 1982), a granitic batholith in central Idaho, than it is like nearer RRH in the target watershed. Limestone ranges occur in eastern portions of the Ecoregion. The Northern Basin and Range Ecoregion can probably be divided into 8 to 10 types of geologic district.

Attributes reflecting the existing state of survey stations, sorted by geologic districts are listed in APPENDIX B. Stream substrate was mostly gravel and rubble in the sedimentary and volcanic districts while that in the tuffaceous district was mostly fines.

Descriptions of geologic districts were developed for the target watershed. It is likely that the range in characteristics will be broadened if applied over larger regions of more diverse character. The names of geologic districts will then need to be more specific (e.g. volcanic/rhyolite, volcanic/basalt) to adequately specify geologic districts throughout the Northern Basin and Range Ecoregion. Geologic districts were divided into areas of more homogeneous geomorphic character.

The average drainage density was calculated for each geologic district (length streams/area). Results are listed in Table 4.2-4. While the drainage densities for all streams (intermittent and perennial) are similar, that for perennial streams are different, indicating fundamental differences in the hydrologic character of geologic districts.

Table 4.2-4. Drainage density for geologic districts.

GEOLOGIC DISTRICT	---DRAINAGE DENSITY---- (All)	(Perennial)
SEDIMENTARY (1000)	2.46	0.70
VOLCANIC (2000)	2.84	0.24
TUFFACEOUS (3000)	2.94	0.33

Geologic districts containing soft rock that weathers rapidly to fine sediment appeared to respond to alternative livestock management faster than areas of hard rock that weathers slowly to coarse sediment. Streambanks in the tuffaceous geologic district, characterized by an abundance of fine sediment, are more susceptible to deterioration when overgrazed than are streambanks in the sedimentary geologic district, characterized by a moderate supply of mixed sediment sizes. Streams in the tuffaceous district also responded more rapidly to rest, presumably due to the ample supply of fine sediment with high water holding capacity. In livestock exclosures in the tuffaceous district, a moderate degree of restoration was apparent after only two seasons of rest. A similar degree of restoration required 5 to 10 years of rest for a similar setting in the sedimentary geologic district. We also expect that differences in attainable water quality can be ascribed to geologic districts.

Table 4.2-3. Stream attributes for geologic districts.

GEOLOGIC DISTRICT	ORDER	-----PERENNIAL------			---INTERMITTENT----		
		N	Length (miles)	Grade (%)	N	Length (miles)	Grade (%)
SEDIMENTARY (1000)	1	73	37.7	14.1	437	194.9	10.8
	2	82	34.3	7.5	102	35.3	5.8
	3	66	18.0	3.8	17	7.0	3.6
	4	20	4.8	2.1	1	0.2	0.4
TOTAL		**241**	**94.8**	**9.2**	**557**	**237.4**	**9.9**
VOLCANIC (2000)	1	5	1.9	5.3	472	218.5	5.9
	2	16	4.8	3.4	169	62.1	3.4
	3	23	7.6	3.0	72	30.6	2.0
	4	5	1.2	4.3	6	2.2	1.2
	5	28	8.7	0.6	12	4.0	2.1
	6	8	5.6	0.2	13	[illegible]	1.9
TOTAL		**85**	**29.9**	**2.0**	**744**	**321.9**	**4.9**
TUFFACEOUS (3000)	1	0	0.0	-	647	488.5	2.7
	2	0	0.0	-	331	202.4	1.8
	3	77	33.9	1.1	151	83.9	1.3
	4	87	29.8	1.1	54	20.7	0.9
	5	63	32.3	0.3	31	15.1	0.3
	6	7	5.6	0.2	0	0.0	0.0
TOTAL		**234**	**101.6**	**0.8**	**1214**	**810.6**	**2.3**

(1) Data from 1:24,000 scale quads (USGS); elevations extrapolated from 20 and 40 foot contours.

For streams of the same order, gradient was generally highest in the sedimentary geologic district and lowest for the tuffaceous district. This makes sense, given the high relief in the sedimentary district, moderate relief in the volcanic district and the low relief in the tuffaceous district. Contrary to this trend, order 4 streams in the volcanic district are of higher gradient than those in the sedimentary district, possibly reflecting differences in drainage pattern.

Qa = Quaternary alluvium
Qg = Quaternary glacial deposits (moraines)
Qls = Quaternary landslide deposits
Qta = Older alluvium
Tgr = Tertiary granite
Ta3 = Tertiary pyroclastic rocks
Tjr = Tertiary Jarbidge rhyolite
Ts3 = Tertiary tuffaceous sedimentary rock
Tt2 = Tertiary welded tuff
Ta2 = Tertiary pyroclastic rock (andesite)
Ts2 = Tertiary tuffaceous and clastic rock
Tt1 = Tertiary silicic vocanic rock (rhyolite, tuff, welded tuff)
Ta1 = Tertiary andesite and pyroclastic rock
Ts1 = Tertiary sedimentary rock (limestone, conglomerate, sandstone, shale)
Tc = Tertiary conglomerate
TrPc = Triassic marine conglomerate
[PMs = Pensylvanian/Mississippian conglomerate, sandstone and shale
Pem = Permian Edna Mtn. Frm. (coarse-grained sandstone)
P[Pcs = Permian Carlin sequence
[PMdp = Permian Diamond Peak Frm. (conglomerate, sandstone, shale)
Mc = Mississippian shale and sandstone
Ppc = Permian carbonate and detrital rocks
PMI = Permian and Mississippian limestone, shale, chert, orthoquartzite
Dos = Devonian mudstone, shale, chert, siltstone, quartzite
DSrm = Devonian/Silurian Roberts Mtn. Frm. (silty limestone and dolomite)
Dl = Devonian limestone
SOh = Silurian/Ordivician Hanson Cr. Frm. (limestone and dolomite)
Cc = Cambrian carbonitic rocks

Table 4.2-1. Geologic districts, North Fork Humboldt study area.

GEOLOGIC DISTRICT	CODE	AREA (square miles)	PERCENT WATERSHED
Sedimentary	1000	134.8	23.7
Volcanic	2000	123.9	21.8
Tuffaceous	3000	310.4	54.5

Table 4.2-2. Rock types comprising geologic districts (Coats 1987).

Rock Type (1)	GEOLOGIC DISTRICT 1000 (mi^2)	1000 (%)	2000 (mi^2)	2000 (%)	3000 (mi^2)	3000 (%)
Qa	2.7	17.5	6.4	5.3	60.7	19.6
Qg	8.9	6.8	-	-	0.1	0.0
Qls	2.9	2.2	0.4	0.4	0.4	0.1
Qta	0.2	0.2	1.4	1.1	13.0	4.2
Tgr	2.5	2.0	-	-	0.1	0.0
Ta3	-	-	1.7	1.4	0.1	0.0
Tjr	-	-	3.9	3.2	0.5	0.2
Ts3	1.3	1.0	4.4	3.6	225.2	72.9
Tt2	0.6	0.5	22.5	18.4	2.2	0.7
Ta2	0.3	0.2	8.4	6.8	0.6	0.2
Ts2	-	-	0.8	0.7	0.1	0.0
Tt1	1.5	1.2	57.3	46.8	4.7	1.5
Ta1	0.3	0.2	9.3	7.6	0.3	0.1
Ts1	0.1	0.1	2.2	1.8	-	-
Tc	0.1	0.1	0.3	0.2	0.1	0.0
TrPc	0.1	0.1	-	-	-	-
[PMs	8.7	6.7	-	-	-	-
Pem	1.0	0.8	0.2	0.2	-	-
P[Pcs	1.7	1.3	-	-	-	-
[PMdp	19.2	14.8	0.4	0.2	0.1	0.0
Mc	5.9	4.5	0.1	0.1	0.3	0.1
Ppc	0.1	0.0	0.1	0.0	-	-
PMI	3.9	3.0	-	-	-	-
Dos	59.0	45.5	2.6	2.1	0.6	0.2
DSrm	4.9	3.8	-	-	-	-
Dl	0.7	0.6	-	-	-	-
SOh	0.7	0.5	-	-	-	-
Cc	2.5	1.9	-	-	-	-
TOTAL	**123.8**	**100.0**	**123.9**	**100.0**	**310.4**	**100.0**

(1) Rock type legend follows.

Rock Type Legend

This page is intentionally blank.

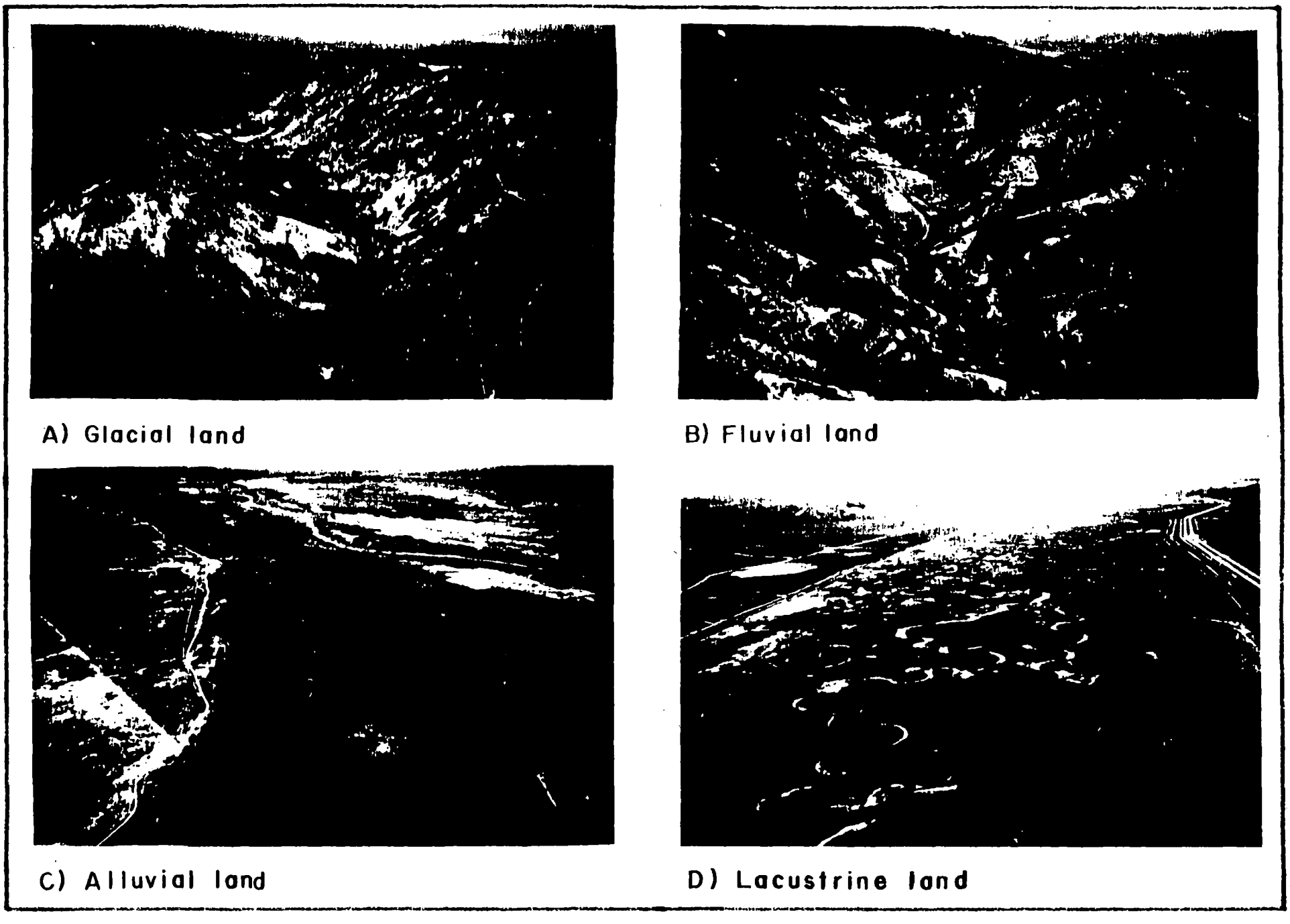


Figure 4.3-1. Geomorphic classes, North Fork Humboldt study area.

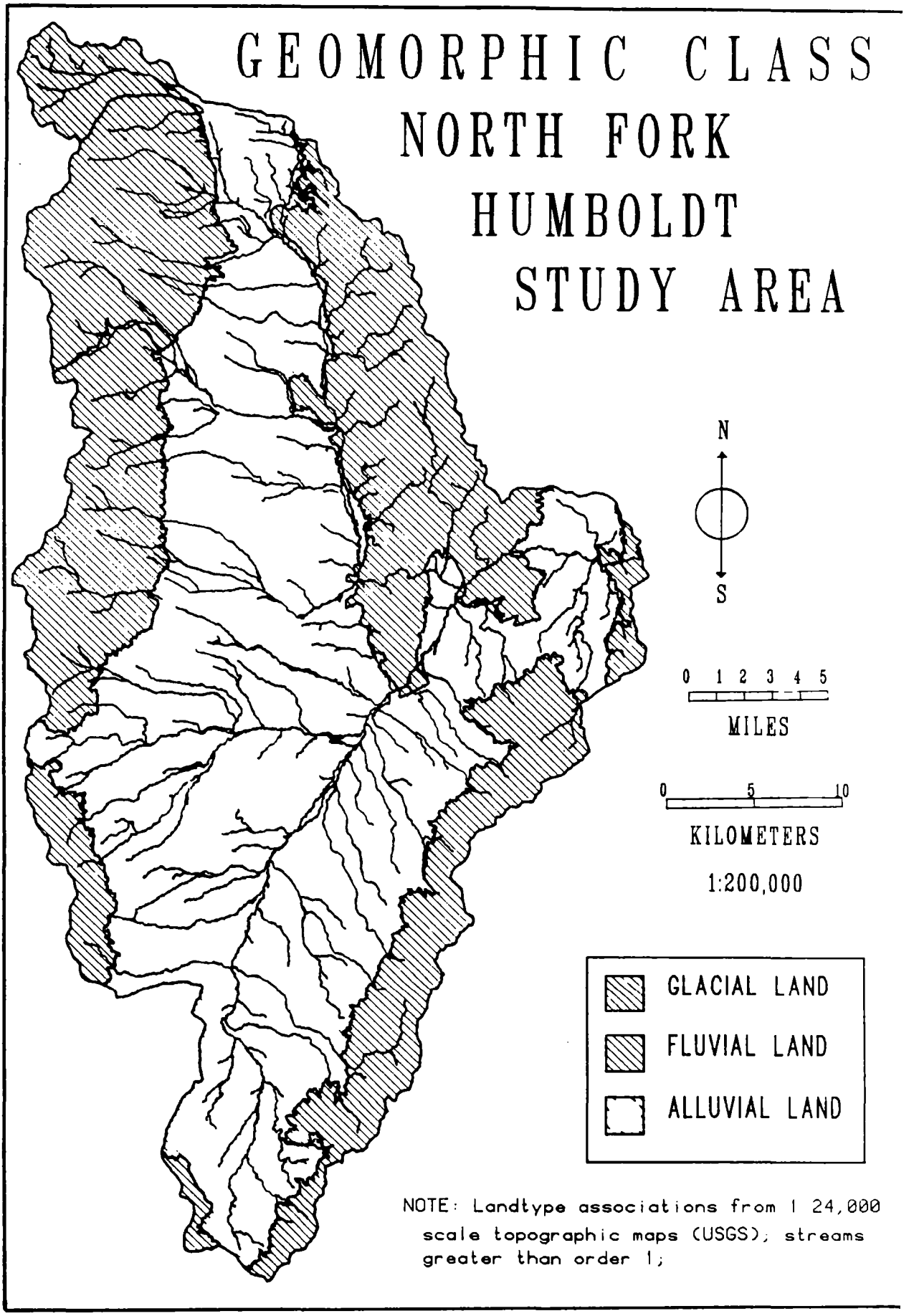

GEOMORPHIC CLASS
NORTH FORK
HUMBOLDT
STUDY AREA
N
S
0 1 2 3 4 5
MILES
0 5 10
KILOMETERS
1:200,000
GLACIAL LAND
FLUVIAL LAND
ALLUVIAL LAND
NOTE: Landtype associations from 1 24,000 scale topographic maps (USGS); streams greater than order 1;

Figure 4.3-2

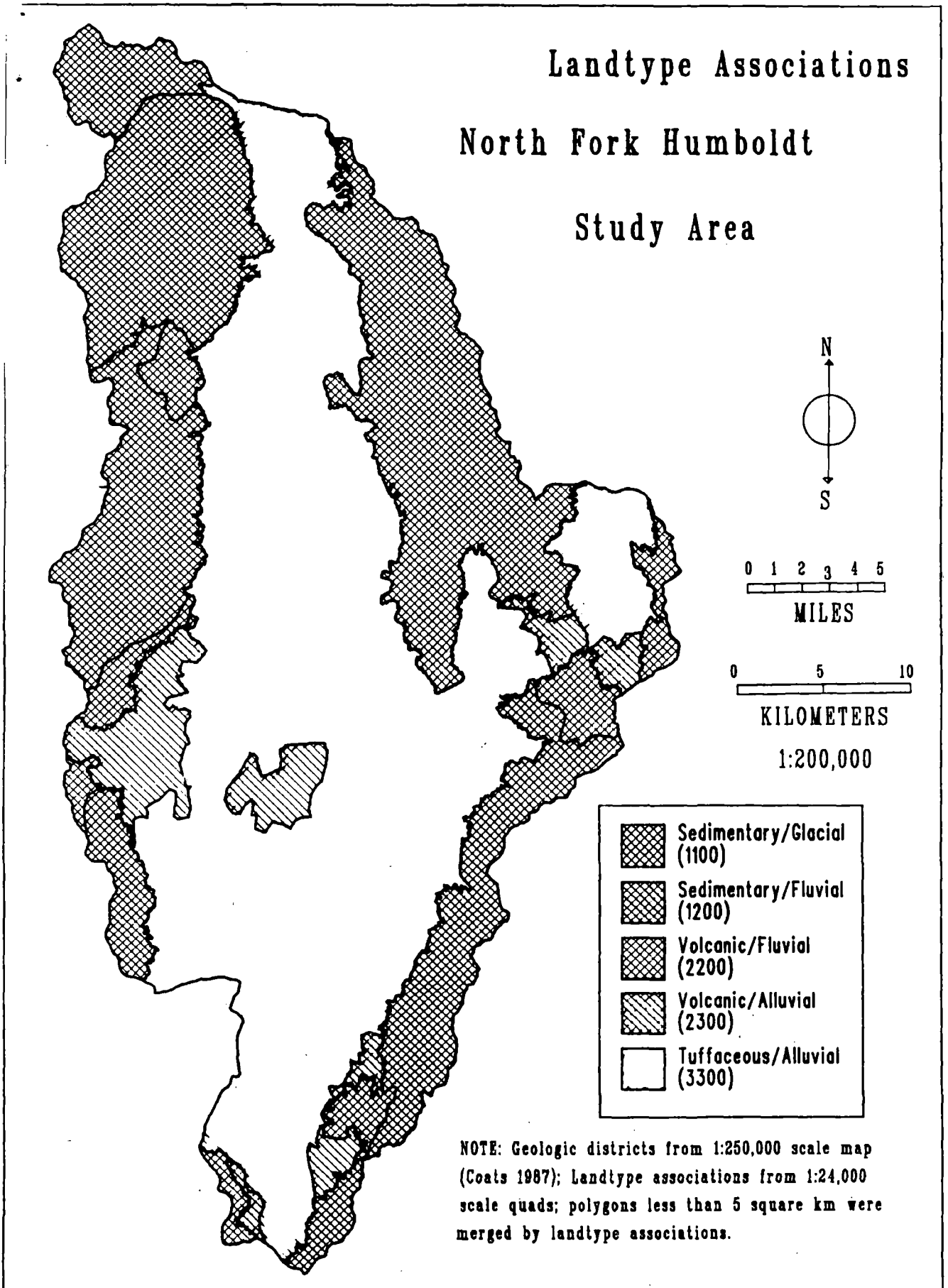

Landtype Associations
North Fork Humboldt
Study Area
N
S
0 1 2 3 4 5
MILES
0 5 10
KILOMETERS
1:200,000
Sedimentary/Glacial (1100)
Sedimentary/Fluvial (1200)
Volcanic/Fluvial (2200)
Volcanic/Alluvial (2300)
Tuffaceous/Alluvial (3300)
NOTE: Geologic districts from 1:250,000 scale map (Coats 1987); Landtype associations from 1:24,000 scale quads; polygons less than 5 square km were merged by landtype associations.

Figure 4.3-3

Table 4.3-1. Landtype association legend, North Fork Humboldt study area.

GEOLOGIC DISTRICT Landtype Association	CODE	AREA (square miles)	PERCENT WATERSHED
SEDIMENTARY (1)			
Glacial land	1100	50.7	8.5
Fluvial land	1200	102.6	17.2
VOLCANIC (2)			
Fluvial land	2200	97.3	16.8
Alluvial land	2300	37.9	6.3
TUFFACEOUS (3)			
Alluvial land	3300	308.2	51.2
TOTAL		**596.9**	**100.0**

NOTE: Polygons less than 3 square miles were treated as inclusions of contrasting geologic districts within the landtype association. Delineations of geologic districts (from 1:250,000 scale) were less precise than landtype associations (from 1:24,000 scale).

(1) Small areas of the volcanic (2000) geologic district comprise about 0.4 percent of glacial land; fluvial land includes about 0.5 percent volcanic (2000) and 3.9 percent tuffaceous (3000) geologic districts.

(2) Fluvial land includes about 4.8 percent sedimentary (1000) and 13.2 percent tuffaceous (3000) geologic districts; alluvial land includes about 1.0 percent sedimentary (1000) and 2.7 percent tuffaceous (3000) geologic districts.

(3) Alluvial land includes about 2.7 percent sedimentary (1000) and 3.0 percent volcanic (2000) geologic districts.

Table 4.3-2. Stream attributes for landtype associations.

GEOLOGIC DISTRICT / LANDTYPE ASSOCIATION	ORDER	PERENNIAL N	PERENNIAL Length (miles)	PERENNIAL Grade* (%)	INTERMITTENT N	INTERMITTENT Length (miles)	INTERMITTENT Grade* (%)
SEDIMENTARY							
1100	1	36	19.6	15.3	102	49.2	8.8
1100	2	34	17.7	8.9	28	12	4.0
1100	3	27	7.4	3.5	4	4.2	3.3
1100	4	3	1.6	1.9	0	0	0
	TOTAL	**100**	**46.3**	**10.5**	**134**	**65.4**	**7.6**
1200	1	37	18.1	12.9	335	145.7	11.5
1200	2	48	16.5	6.0	74	23.4	6.8
1200	3	39	10.6	4.0	13	2.8	4.0
1200	4	17	3.3	2.2	1	0.2	0.4
	TOTAL	**141**	**48.5**	**7.9**	**423**	**172**	**10.7**
VOLCANIC							
2200	1	5	1.9	5.3	360	151.2	6.8
2200	2	16	4.8	3.4	118	41.1	3.9
2200	3	9	2.9	3.5	40	14.5	2.6
2200	4	5	1.2	4.3	4	1.6	1.5
2200	5	28	8.7	0.6	0	0	-
2200	6	8	5.6	0.2	0	0	-
	TOTAL	**71**	**25.2**	**1.9**	**522**	**208.5**	**5.9**
2300	1	0	0	-	112	67.3	3.8
2300	2	0	0	-	51	20.9	2.4
2300	3	14	4.7	2.6	32	16.1	1.4
2300	4	0	0	-	2	0.6	0.5
	TOTAL	**14**	**4.7**	**2.6**	**197**	**105**	**3.1**
TUFFACEOUS							
3300	1	12	4	2.1	647	488.5	2.7
3300	2	13	4.4	1.9	331	202.4	1.8
3300	3	77	33.9	1.1	151	83.9	1.3
3300	4	87	29.8	1.1	54	20.7	0.9
3300	5	63	32.3	0.3	31	15.1	0.3
3300	6	7	5.6	0.2	0	0	-
	TOTAL	**259**	**110.1**	**0.9**	**1214**	**810.6**	**2.3**

In the sedimentary geologic district, the proportion of perennial to intermittent streams in glacial land was about twice that of fluvial lands, probably reflecting greater precipitation at the higher elevations. A similar relationship was observed between fluvial and alluvial lands in the volcanic geologic district. The gradients listed were measured from 1:24,000 scale maps and are closer to valley gradients than to stream gradients. Stream gradients will be lower than valley gradients by a factor of the sinuosity ratio.

Different landtype associations tend to respond to nps impacts through different mechanisms or through the same mechanisms but at different rates. They may also respond in differing degrees under the same intensity of use. In the sedimentary geologic district, streams in glacial lands with rubble substrate respond to overgrazing by an increase in channel width with little change in channel depth whereas the change in ground water level in fluvial lands tend to incise. The response in glacial lands results in little change in alluvial groundwater level whereas the response in fluvial lands is great. While streams in fluvial lands of both sedimentary and volcanic geologic districts (1200 and 2200 landtype associations) tend to incise, the latter are less susceptible, presumably due to shallower depths of valley fill, less precipitation due to lower elevations and differences in the timing of runoff.

Different landtype associations within the same geologic district tend to have contrasting channel substrates, pool features and channel form. Stream attributes measured to describe the existing state of survey stations, are sorted by landtype association in APPENDIX C.

4.4 Landtype

Of the many landtypes in the target watershed (e.g. cirque, ridgecrest, hill slope, etc.) only the valley-bottom, where streams and riparian habitat occur, was identified (see Figure 4.4-1). An inventory of **valley-bottom landtypes** was generated by overlaying the map of the valley bottom with the map of landtype associations (see Figure 4.3-3). The inventory is summarized in Table 4.4-1.

Table 4.4-1. Area of the valley-bottom within landtype associations (LA).

LANDTYPE ASSOCIATION	--------VALLEY-BOTTOM LANDTYPE-------- AREA (square miles)	PROPORTION LA (%)	PROPORTION STUDY AREA (%)
SEDIMENTARY/GLACIAL (1100)	6.1	12.0	1.0
SEDIMENTARY/FLUVIAL (1200)	4.7	4.6	0.8
VOLCANIC/FLUVIAL (2200)	5.8	6.0	1.0
VOLCANIC/ALLUVIAL (2300)	3.9	10.3	0.7
TUFFACEOUS/ALLUVIAL (3300)	59.0	19.1	9.5
TOTAL	**79.5**	--	**13.0**

The proportion of the valley-bottom landtype varied considerably between different landtype associations. Cattle tend to spend more time in the valley-bottom landtype where water, vegetation and shade are more abundant. The same stocking rate in the 1200 landtype association will result in greater concentration of livestock along streams and in riparian areas than in the 3300 landtype association, simply due to differences in the area of the valley-bottom landtype relative to the landtype association. The proportion of the valley-bottom landtype for different landtype associations may serve as a rough guide for adjusting livestock numbers to protect streams and riparian habitat.

4.5 Valley Bottom Types

Valley-bottom types are subsets of valley-bottom landtypes, distinguished by position, morphology and functional attributes. Each valley-bottom type (VBT) in the target watershed is discussed below.

Glacial Basin (1110 VBT): zone of glacial erosion; valley-bottoms are scoured, sometimes with a dispersed veneer of glacial till and erratics; moraines, if present are generally discontinuous; includes the valley-bottom above the base of terminal moraines; upland vegetation covers much of the valley-bottom; elevations range from about 7,200 to 9,520 feet.

Glacial Train (1120 VBT): zone of glacial transport; lateral moraines with upland vegetation confine the floodplain on one or both sides of the channel; occurs below glacial basin; channel substrates are mostly cobble; streams tend to be braided with little channel incision due to coarse substrate; elevations range from about 6,800 to 8,000 feet.

Glacial Outwash (1130 VBT): zone of glacial deposition; forms broad outwash plains of cobbly sediment; occurs below glacial train; outwash from meltdown of glaciers; forms extensive plains of cobbly sediment; streamflow depleted by excessive bedloss through coarse substrate; bedloss resurfaces as springs near base of glacial outwash; elevations range from about 6,300 to 6,800 feet.

Fluvial (V-shaped) erosional (1210 and 2210 VBTs): zone of fluvial erosion; common in the headwaters (low order streams) of fluvial lands; valley-bottoms are narrow; alluvial and residual landforms commonly flank the stream channel; floodplains and levees are discontinuous along streambanks; generally associated with high-gradient streams; perennial streams are mostly springfed; stream sinuosity is low; streams are downcutting into consolidated strata and headcutting toward drainage divides; elevations range from about 5,800 to 7,400 feet; position, morphology and functional attributes are similar in the sedimentary (1210 VBT) and volcanic (2210 VBT) geologic districts, although hydrologic characteristics are markedly dissimilar.

Fluvial (V-shaped) depositional (1220 and 2220 VBTs): zone of fluvial deposition; common in lower elevations of fluvial lands where the valley has been filled to some depth by sediments transported from upstream sources; floodplains and levees are generally continuous along streambanks; may also include discontinuous channel segments with residual or alluvial landforms on one or both side of stream channel; generally includes moderate gradient streams; elevations range from about 5,700 to 7,700 feet; position, morphology and functional attributes are similar in the sedimentary (1220 VBT) and volcanic (2220 VBT) geologic districts, although hydrologic characteristics are markedly dissimilar.

Fluvial (notch-shaped) erosional (2250 VBT): zone of fluvial erosion; streams are incised in deep canyons with nearly vertical escarpments; confined to the volcanic geologic district where strata are oriented horizontally; stream channel flanked by nearly vertical (residual) escarpments or steep (colluvial) talus slopes; stream substrate is generally bedrock with thin veneer of sandy sediment; similar to canyons in the Colorado Plateau and Snake River Basin/High Desert Ecoregions; elevations range from about 5,700 to 6,000 feet.

Fluvial (notch-shaped) depositional (2260 VBT): zone of fluvial deposition; confined to the volcanic geologic district the stream channel is flanked by levees and floodplain; stream substrate is generally sand and cobble; resembles canyons of the Snake River Basin/High Desert Ecoregion; canyon bottoms are 100 to 200 feet below the surrounding landscape; elevations range from about 5,600 to 5,900 feet.

Alluvial confined floodplain (2310 and 3310 VBTs): valley-bottoms are 30 to 75 feet below the surrounding landscape; valley-bottom width is generally less than 180 feet; floodplains are abruptly confined by residual slopes (mostly of ash-flow tuff but also volcanic rock); includes the courses of streams originating in fluvial land that are generally transverse to the north-south axis of the intermontane valley; stream substrates are commonly gravelly near the mountain fronts and become finer toward the valley axis; elevations range from about 5,600 to 6,400 feet; the drainage pattern in the volcanic district (2310 VBT) is determined by jointing of the parent rock in contrast to the drainage pattern in the tuffaceous district (3310 VBT).

Alluvial unconfined floodplain (3320 VBT): includes high order stream courses that are oriented more-or-less parallel to the axis of the intermontane valley; valley-bottom is generally greater than 500 feet wide; streams are mostly perennial; floodplains are less abruptly confined and are commonly flanked by alluvial transitions; associated with high-order, sinuous streams; elevations range from about 5,600 to 6,100 feet.

Valley-bottom types are illustrated in Figure 4.5-1 through 4.5-3 and delineated in Figure 4.5-4. The areas of valley-bottom types and their relative proportion in the watershed are listed in Table 4.5-1. Stream attributes, measured from 1:24,000 scale USGS quads, are summarized in Table 4.5-2.

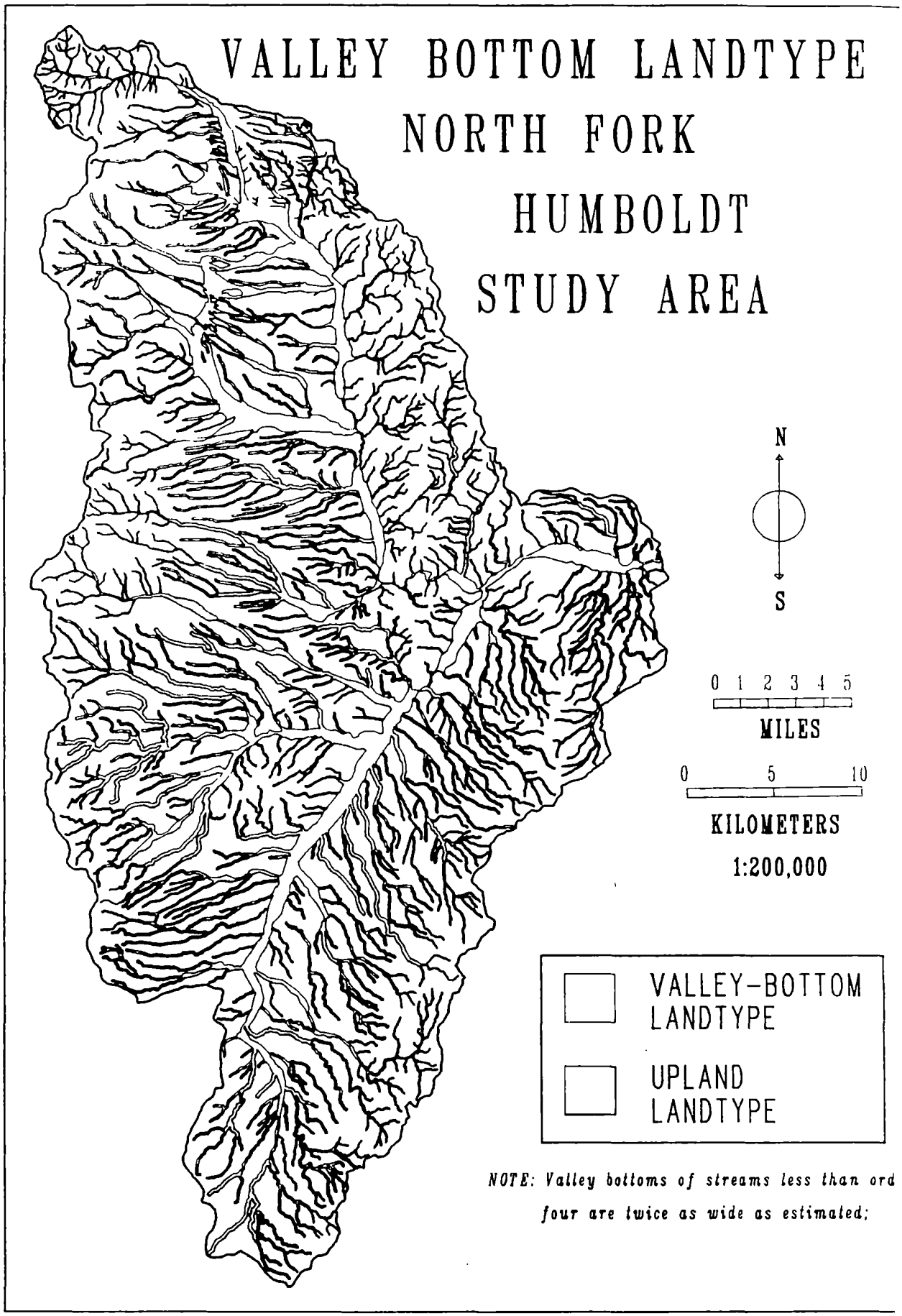

VALLEY BOTTOM LANDTYPE
NORTH FORK
HUMBOLDT
STUDY AREA
N
S
0 1 2 3 4 5
MILES
0 5 10
KILOMETERS
1:200,000
VALLEY-BOTTOM LANDTYPE
UPLAND LANDTYPE
NOTE: Valley bottoms of streams less than ord four are twice as wide as estimated;

Figure 4.4-1

A) Glacial basin (1110 VBT).

B) Glacial train (1120 VBT).

C) Glacial outwash (1130 VBT).

Figure 4.5-1. Valley-bottom types, glacial land.

A) V (shaped) erosional (1210 VBT)

B) V (shaped) depositional (1220 VBT)

C) Notch (shaped) erosional (2250 VBT).

D) Notch (shaped) depositional (2260 VBT).

Figure 4.5-2. Valley-bottom types, fluvial land.

A) Confined floodplain

B) Unconfined floodplain

Figure 4.5-3. Valley-bottom types, alluvial land.

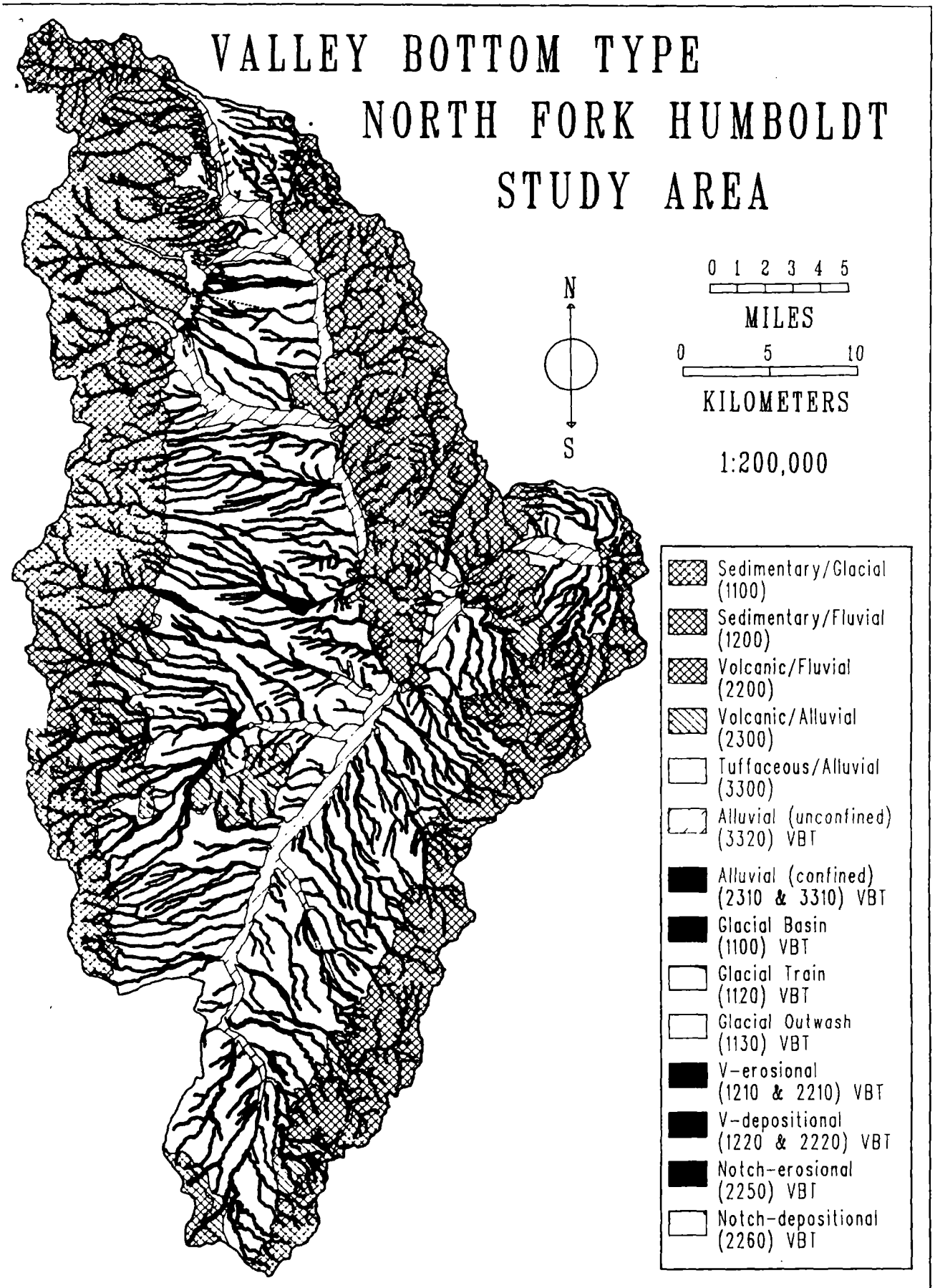

VALLEY BOTTOM TYPE
NORTH FORK HUMBOLDT
STUDY AREA
N
S
0 1 2 3 4 5
MILES
0 5 10
KILOMETERS
1:200,000
Sedimentary/Glacial (1100)
Sedimentary/Fluvial (1200)
Volcanic/Fluvial (2200)
Volcanic/Alluvial (2300)
Tuffaceous/Alluvial (3300)
Alluvial (unconfined) (3320) VBT
Alluvial (confined) (2310 & 3310) VBT
Glacial Basin (1100) VBT
Glacial Train (1120) VBT
Glacial Outwash (1130) VBT
V-erosional (1210 & 2210) VBT
V-depositional (1220 & 2220) VBT
Notch-erosional (2250) VBT
Notch-depositional (2260) VBT

Figure 4.5-4

In glacial lands, perennial streams are prevalent in glacial basins (1110 VBT), less prevalent in glacial trains (1120 VBT) and are a minor portion of glacial outwash (1130 VBT). Springs and surface runoff sustain perennial flow in the basins, while bedloss into the fragmental substrate reduces surface flow through trains and commonly depletes flow across outwash plains. Groundwater commonly surface as springs near the base of the glacial outwash.

In fluvial lands, intermittent streams are prevalent in V-shaped erosional (1210 and 2210) valley bottom types forming the heads of watersheds and less common in V-shaped depositional (1220 and 2220) valley-bottom types in lower drainage positions, indicating a more random distribution of runoff and spring sources. A similar contrast was observed between valley bottom types in alluvial lands (3310 and 3320 VBTs) where perennial flow was most prevalent in the unconfined valley-bottom type.

The distributions of gradients for all stream reaches in each valley-bottom type are illustrated in Figure 4.5-5. The distributions are distinctive for contrasting valley-bottom types, but the gradients for similar valley-bottom types (e.g. 1210 and 2210; 1220 and 2220; 3210 and 3310) are comparable. Gradients were measured from 1:24,000 scale quads and are closer to valley gradient than to stream gradient because much of the stream sinuosity was not discernible at this scale.

Stream attributes, quantifications of the existing states of survey stations, are listed in APPENDIX D.

Table 4.5-2. Continued.

VALLEY-BOTTOM TYPE	ORDER	PERENNIAL N	PERENNIAL Length (miles)	PERENNIAL Grade (%)	INTERMITTENT N	INTERMITTENT Length (miles)	INTERMITTENT Grade (%)
2260	1	0	--	--	8	1.5	1.7
2260	2	1	0.1	0.3	3	0.2	0.7
2260	3	1	0.1	0.9	2	0.7	1.7
2260	4	1	0.1	0.3	0	--	--
2260	5	14	4.1	0.3	0	--	--
2260	6	8	5.6	0.2	0	--	--
TOTAL		**25**	**9.9**	**0.2**	**13**	**2.5**	**1.6**
2310	1	0	--	--	112	67.3	3.8
2310	2	0	--	--	51	20.9	2.4
2310	3	14	4.7	2.6	32	16.1	1.4
2310	4	0	--	--	2	0.6	0.5
TOTAL		**14**	**4.7**	**2.6**	**197**	**105.0**	**3.1**
3310	1	6	2.4	3.2	543	457.8	2.8
3310	2	9	3.2	2.2	267	182.3	1.9
3310	3	50	25.8	1.2	110	68.4	1.4
3310	4	15	4.7	0.9	24	12.4	1.0
TOTAL		**80**	**36.1**	**1.4**	**944**	**720.9**	**2.4**
3320	1	6	1.6	0.6	104	30.6	1.7
3320	2	4	1.2	1.2	64	20.1	1.0
3320	3	27	8.1	1.0	41	15.6	0.9
3320	4	72	25.2	1.2	30	8.3	0.9
3320	5	63	32.3	0.3	31	15.1	0.3
3320	6	7	5.6	0.2	0	--	--
TOTAL		**179**	**74.0**	**0.7**	**270**	**89.7**	**1.1**

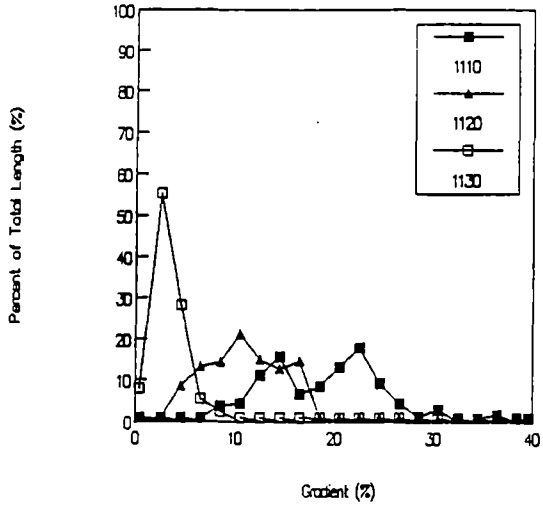
Differences in the average gradient of same-order streams were evident between valley-bottom types in the same landtype association. In glacial lands (1110, 1120 and 1130 VBTs) average gradients for order 1 streams varied from 18.6 to 4.4 percent; similar differences were evident in fluvial and alluvial lands.

Table 4.5-2. Stream attributes for valley-bottom types.

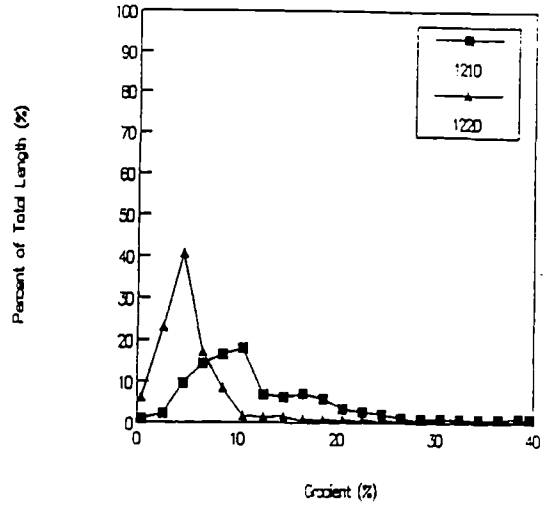
VALLEY-BOTTOM TYPE	ORDER	PERENNIAL N	PERENNIAL Length (miles)	PERENNIAL Grade (%)	INTERMITTENT N	INTERMITTENT Length (miles)	INTERMITTENT Grade (%)
1110	1	21	12.6	18.6	18	10.8	21.1
1110	2	12	2.6	13.9	4	0.7	17.0
TOTAL		**33**	**15.3**	**17.8**	**22**	**11.5**	**20.9**
1120	1	6	4.4	12.2	18	9.4	10.8
1120	2	11	8.4	11.4	1	0.6	12.4
1120	3	4	1.4	5.8	--	--	--
TOTAL		**21**	**14.2**	**11.1**	**19**	**10.0**	**10.9**
1130	1	9	2.6	4.4	66	29.0	3.6
1130	2	11	6.7	4.0	23	10.6	2.6
1130	3	23	6.0	3.0	4	4.2	3.3
1130	4	3	1.6	1.9	--	--	--
TOTAL		**46**	**16.9**	**3.5**	**93**	**43.9**	**3.3**
1210	1	28	15.1	14.0	238	119.7	12.7
1210	2	22	7.5	7.6	36	11.7	8.3
1210	3	5	1.4	10.2	6	1.5	5.5
TOTAL		**55**	**23.9**	**11.8**	**280**	**132.8**	**12.2**
1220	1	9	3.1	7.3	97	26.0	6.0
1220	2	26	9.1	4.6	38	11.7	5.2
1220	3	34	9.2	3.1	7	1.3	2.3
1220	4	17	3.3	2.2	1	0.2	0.4
TOTAL		**86**	**24.6**	**4.1**	**143**	**39.1**	**5.6**
2210	1	1	0.5	6.1	203	99.3	7.8
2210	2	0	--	--	25	6.4	5.2
2210	3	1	0.1	5.7	4	0.9	4.4
TOTAL		**2**	**0.6**	**6.0**	**232**	**106.6**	**7.6**
2220	1	4	1.4	5.1	149	50.4	5.1
2220	2	15	4.8	3.5	90	34.6	3.7
2220	3	7	2.7	3.5	34	12.8	2.5
2220	4	4	1.1	4.8	4	1.6	1.5
2220	5	1	0.3	0.6	0	--	--
TOTAL		**31**	**10.3**	**3.8**	**273**	**99.0**	**4.2**
2250	5	13	4.4	0.9	0	--	--
TOTAL		**13**	**4.4**	**0.9**	**0**	--	--

Table 4.5-1. Valley-bottom types (VBTs), North Fork Humboldt study area.

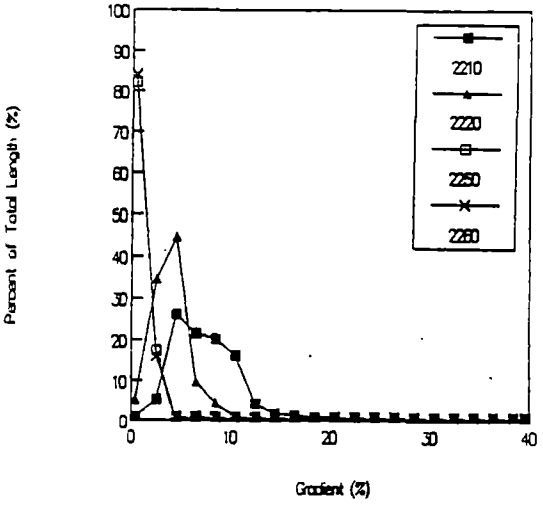
GEOLOGIC DISTRICT Landtype Association (LA) Valley-bottom type	CODE	AREA VBT (mi^2)	PERCENT OF LA
SEDIMENTARY	1000		
Glacial	1100		
Basin	1110	0.8	1.5
Train	1120	1.0	2.0
Outwash	1130	4.3	8.5
Fluvial	1200		
V (shaped)-erosional	1210	3.0	2.9
V (shaped)-depositional	1220	1.7	1.6
VOLCANIC	2000		
Fluvial	2200		
V (shaped)-erosional	2210	2.1	2.2
V (shaped)-depositional	2220	2.5	2.6
Notch (shaped)-erosional	2250	0.3	0.3
Notch (shaped)-depositional	2260	0.9	1.0
Alluvial	2300		
Confined floodplain	2310	3.9	10.3
TUFFACEOUS	3000		
Alluvial	3300		
Confined floodplain	3310	31.5	10.2
Unconfined floodplain	3320	27.5	8.4



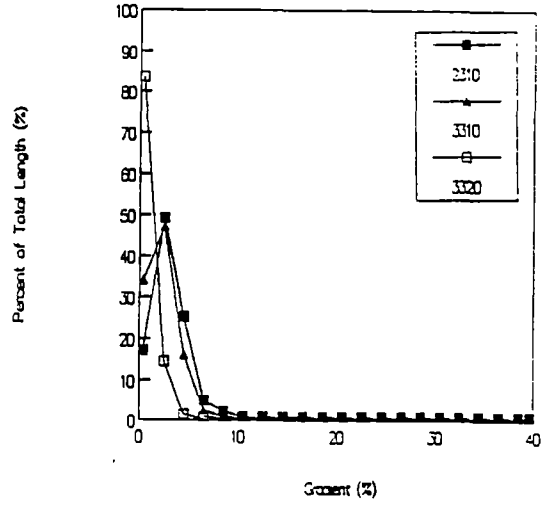
A) Sedimentary/glacial (1100 LA).



B) Sedimentary/fluvial (1200 LA).



C) Volcanic/fluvial (2200 LA).



D) Alluvial (2300 and 3300 LAs).

Figure 4.5-5. Percent distribution of stream gradient.

4.6 Landforms

Landforms identified in the valley-bottom landtype are defined below.

channel: the area between the streambanks; for a graded channel, the area containing moderate to high flow; includes the stream, streambars and vertical aspects of upper banks; substrates are usually similar to the stream bottom and demonstrate little soil development; occur in all valley-bottom types; the dimensions of the channel can change in response to cultural practices.

levee: narrow, convex forms along streams which restrict the lateral distribution of moderate to high flow; surfaces are hummocky or undulating; coarse fragments (gravel or cobble) are distributed throughout the depth of the profile, with little sorting; migration of the channel can leave levees stranded across the valley bottom; levees occur in all valley-bottom types but are most prevalent in glacial and fluvial lands; levees are reworked floodplain sediments; commonly dominated by riparian vegetation.

floodplain: the portion of the valley bottom that is built of sediments deposited by streams, which is inundated during bank overflow; surfaces are smooth and even; coarse fragments (gravel and cobble) are sorted and confined to deeper horizons; surface horizons are stratified, fine-textured sediment indicating several depositional events; soils are well developed; when channels become deeply incised, floodplains become stream terraces; floodplains are of minor extent in glacial land, moderate extent in fluvial lands and major extent in alluvial land; commonly dominated by riparian vegetation.

alluvial fan: a broadly convex landform deposited immediately above a confluence with a higher order tributary or at the base of a mountain slope; soils are stratified and well developed; alluvial fans are of minor extent in glacial land, of major extent in V-shaped erosional (1210 and 2210) valley-bottom types, of moderate extent in V-shaped depositional (1210 and 2210) valley-bottom types and of minor extent in alluvial (2310, 3310 and 3320) valley-bottom types; commonly dominated by upland vegetation.

basin: a broad, concave, glacially-scoured surface restricted to the glacial basin (1110) valley-bottom type; commonly includes both upland and riparian vegetation types.

moraine: a mound or ridge of unstratified glacial drift, chiefly till deposited as glaciers retreated; terminal moraines are remnants of the last glacial advance and were included as the lower extreme of the glacial basins (1110 VBT); lateral moraines occur glacial trains (1120 VBT), where they confine the lateral extent of levee and channel; medial moraines mark the convergence of two glacial paths; soils are poorly-sorted glacial till with rock, ranging from gravel to boulder size, distributed throughout the profile; upland vegetation occurs on moraines.

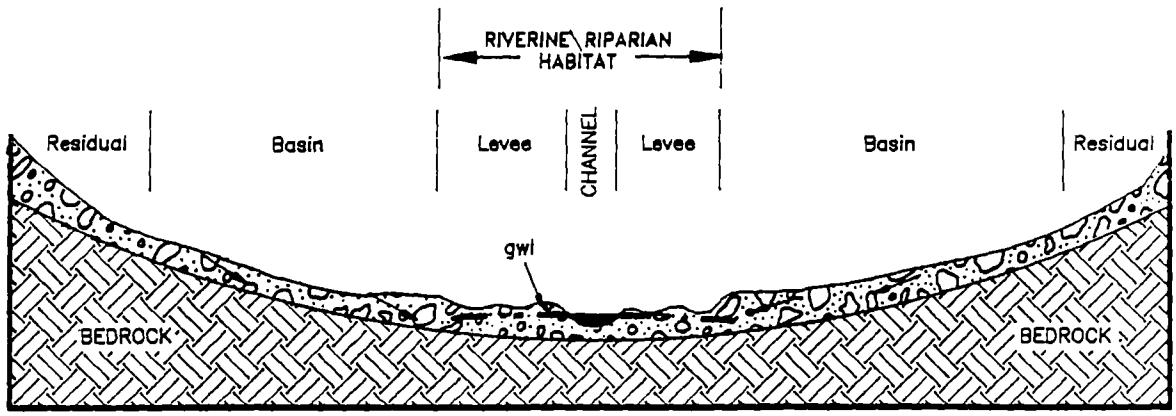
outwash plain: a very broad, convex surface deposited by glacial melt; occurs in glacial outwash (1130 VBT); soils are fragmental throughout; dominated by upland vegetation.

Residual (formed in place) landforms flank all valley-bottom types; they are dominated by upland vegetation except around springs. Colluvial (deposited by gravity) landforms are usually jumbled heaps of angular rock at the angle of repose that sometimes flank the valley bottom in glacial and fluvial lands; they are mostly barren but may include sparse upland vegetation. The typical distribution of landforms among glacial, fluvial and alluvial lands are illustrated, respectively, in Figures 4.6-1, 4.6-2 and 4.6-3, respectively.

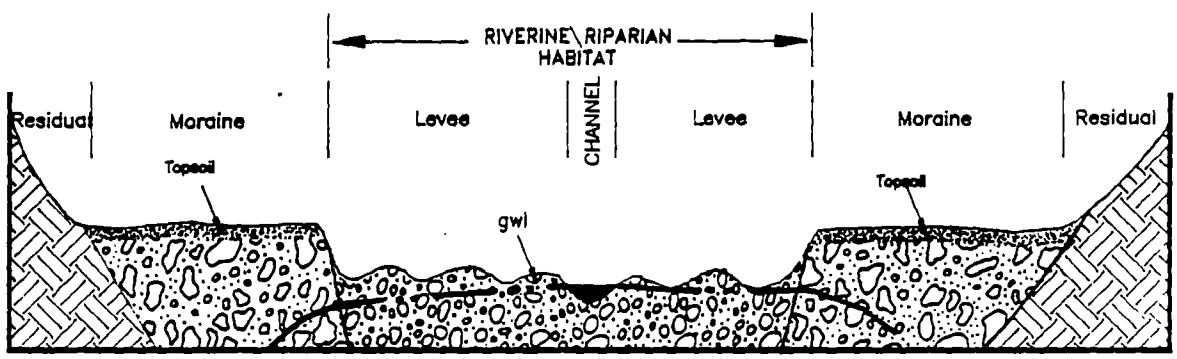
Landforms were mapped from 1:2,000 to 1:4,800 scale CIR photos for selected stream segments. Maps are paired with maps of vegetation types in the Map Supplement Document. Summaries of the areas of landforms and the proportions of vegetation types found on each landform are also presented. Relationships between the distributions of landforms and vegetation types were apparent.

Substrate types are prevalent in stream channels; the dominant size-fraction of substrate varies among valley-bottom types. Riparian shrub vegetation, mostly willows, was common on levees. Herbaceous vegetation, sometimes with an overstory of upland shrubs, dominated floodplains. Upland shrub communities, sometimes complimented by aspen groves, was dominant on alluvial fans and moraines.

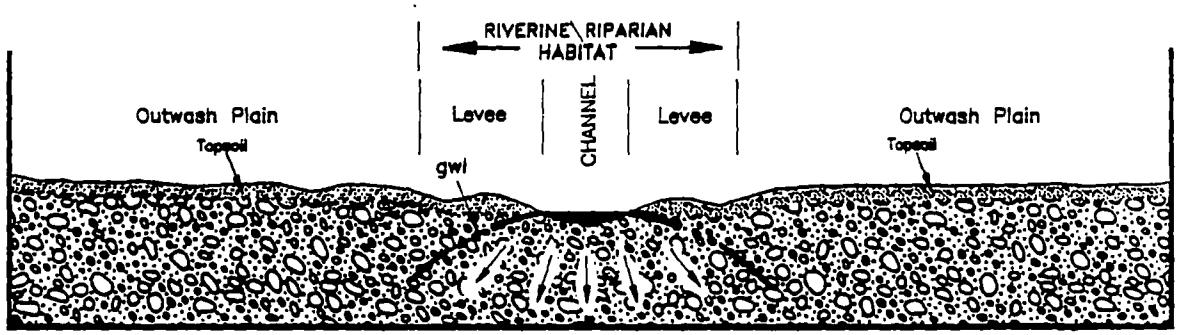
A.) Glacial Basin (1110) VBT



B.) Glacial Train (1120) VBT



C.) Glacial Outwash (1130) VBT



gwl – ground water level
NOTE: Drawings are not to scale.

Figure 4.6-1. Typical distribution of landforms in glacial valley-bottoms.

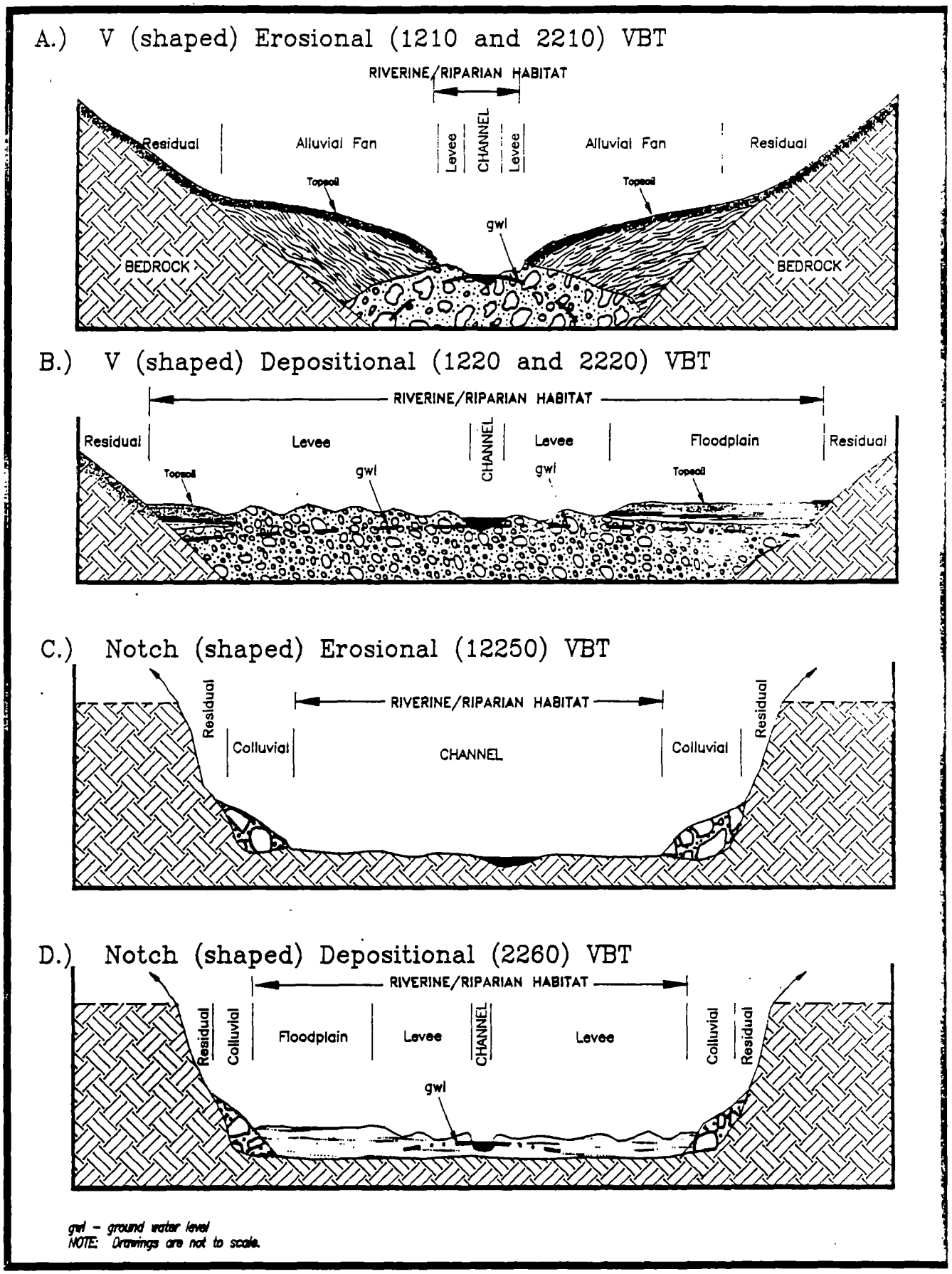
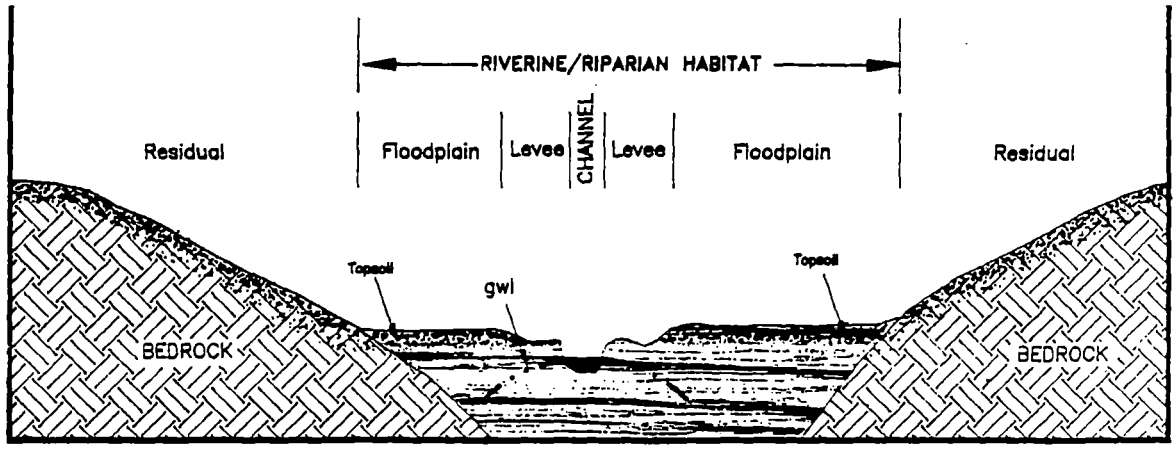
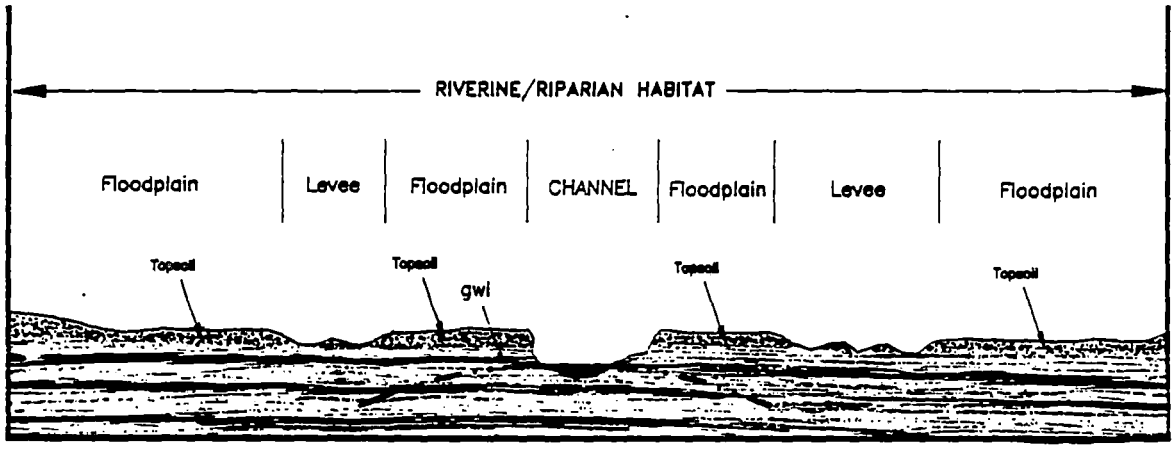


Figure 4.6-2. Typical distribution of landforms in fluvial valley-bottoms.

A.) Alluvial, Confined Floodplain (3310) VBT



B.) Alluvial, Unconfined Floodplain (3320) VBT



gwl – ground water level
NOTE: Drawings are not to scale.

Figure 4.6-3. Typical distribution of landforms in alluvial valley-bottoms.

The water regimes (see Figure 3.1-1) of stream channels are permanently flooded (perennial streams) or intermittently flooded (streambars). Levees and floodplains are seasonally flooded where stream channels are graded, but may become subirrigated or upland where stream channels are incised. Moraines and alluvial fans are seldom (or never) flooded and were designated upland.

Dominant vegetation types for the same landform type tend to vary among different valley-bottom types. Low willows are dominant on levees in glacial basins, while very tall willows mixed with alder and aspen are prevail in glacial train, and mid-size willows are typical of levees in glacial outwash plains. Differences in plant species composition for the same landform type were also observed among different fluvial and alluvial valley-bottom types. These differences in vegetation type for the same landform were attributed to habitat variables of geologic districts, land-type associations and valley-bottom types.

Attributes measured along transects, sorted by bank-forming landform and valley-bottom type, are listed in APPENDIX E. Relative to levees and floodplains, the higher and drier bank forming landforms (e.g. alluvial fans, moraines and residual slopes) tended to correlate with lower bank stability, less vegetation overhang, lower ratio of channel width to depth (corresponding to a greater tendency for channel incision), increase in the ratio of channel width and stream width, and lower pool/riffle ratio and pool rating. These differences were attributed to inherent characteristics of different bank-forming landforms. Stream reaches flanked by levees and floodplains appear to be more sensitive for assessing condition from measurements of stream and channel attributes.

4.7 Vegetation Types

Vegetation types are based on community physiognomy, water regime and plant species dominant in the overstory and understory (see section 3.1 for definitions of physiognomic classes and water regimes). Plant association tables are presented in APPENDIX G. A legend of vegetation types identified in the target watershed is presented in Table 4.7-1. Photos of herbaceous, shrub, forested, upland shrub and substrate vegetation types are presented in Figures 4.7-1 through 4.7-5. Keys for identification of physiognomic classes and vegetation types follow. Preliminary identifications can be verified by referring to vegetation type descriptions (see APPENDIX M). Common names, hydrophytic status and character of plant species are listed in APPENDIX F.

Vegetation types (see APPENDIX M) were based on field descriptions in the vicinities of livestock/fishery study areas (Platts et al. 1988b) and in the target watershed. Concepts for vegetation types should be refined through further studies over larger regions.

Vegetation types were identified along transects of the 110 survey stations; they were also mapped from 1:2,000 to 1:3,500 scale CIR photos for selected stream segments. Assessment of attributes for bank-forming vegetation types are discussed in section 5.4. Maps and data summaries of vegetation types for selected stream reaches in the Map Supplement Document.

A) ROIS AQT (202)

B) MIGU RPT (241)

C) CANE RPT (211)

D) AGST RPT (225)

Figure 4.7-2. Herbaceous vegetation types.

A) SALIX/CAREX RPT (320)

B) SALIX/MH RPT (330)

Figure 4.7-3. Willow dominated vegetation types.

A) POTR/MH RPT

Figure 4.7-4. Populus tremuloides/mesic herbaceous.

A) ARTR/POPR RPT- (340)

B) MXSH/GM RPT- (345)

C) ARTR-CHNA UPT (355)

Figure 4.7-5. Upland shrub vegetation types.

A) Gravel bar RVT (120)

B) Herbaceous gravel bar RVT (125)

C) Cobble bar RVT (130)

Figure 4.7-6. Riverine types.

This page is intentionally blank.

Table 4.7-1. Legend of vegetation types, North Fork Humboldt study area.

PHYSIOGNOMIC CLASS Water Regime Vegetation Type (1)	ACRONYM	CODE (2)	STATUS (3)	POSITION (4)
FORESTED				
Seasonally Flooded				
Populus tremuloides/mesic herbaceous RPT	POTR/MH	540	MJR	BF
Populus angustifolia/mesic herbaceous RPT	POAN/MH	541	MNR	BF
Upland				
Populus tremuloides/upland UPT	POTR-UP	560	MJR	BF
Abies lasiocarpa/upland UPT	ABLA-UP	580	MNR	BF
SHRUB				
Intermittently Flooded				
Salix sp./down woody material RVT	SALIX/DWM	310	MNR	BF-CF
Salix sp./gravel bar RVT	SALIX/GB	312	MJR	CF
Salix sp./cobble bar RVT	SALIX/CB	313	MJR	CF
Semipermanently Flooded				
Salix sp./Carex nebrascensis RPT	SALIX/CANE	320	MJR	BF
Seasonally Flooded				
Salix sp./mesic herbaceous RPT	SALIX/MH	330	MJR	BF
Salix exigua/mesic herbaceous RPT	SAEX/MH	331	MJR	BF
Alnus incana/mesic forb RPT	SALA/MF	334	MJR	BF
Subirrigated				
Artemisia tridentata/Poa pratensis RPT-	ARTR/POPR	340	MJR	BF
Mixed shrub/grass meadow RPT-	MXSH/GM	345	MJR	BF
Upland				
Artemisia sp./upland UPT	ARTR-UP	350	MJR	BF
A. tridentata-C. nauseosus UPT	ARTR-CHNA	355	MJR	BF
Amelanchier sp./upland UPT	AMEL-UP	360	MNR	BF
Purshia tridentata/upland UPT	PUTR-UP	370	MNR	BF
Prunus virginiana/upland UPT	PRVI-UP	380	MNR	BF

(1) AQT = aquatic type; RVT = channel type; RPT = riparian type; RPT- = transitional from riparian to upland type; UPT = upland type

(2) Code for identifying vegetation type on transects and map summaries; codes followed by the same letter were combined for statistical analyses.

(3) STATUS: MJR = Major component of the valley-bottom landtype
MNR = Minor component of the valley-bottom landtype

(4) POSITION: BF = bank forming type; CF = channel forming type

Table 4.7-1. (Continued).

PHYSIOGNOMIC CLASS Water Regime Vegetation Type (1)	ACRONYM	CODE (2)	STATUS (3)	POSITION (4)
HERBACEOUS				
Permanently Flooded				
Wetland complex AQT	WET	201	MNR	CF
Nasturtium officinale AQT	NAOF	202	MNR	CF
Saturated				
Mimulus guttatus RPT	MIGU	241	MNR	NA
Eleocharis palustris RPT	ELPA	242	MNR	BF-CF
Semipermanently Flooded				
Carex nebrascensis RPT	CANE	211	MNR	BF
Carex rostrata RPT	CARO	212	MNR	BF
Seasonally Flooded				
Poa pratensis RPT	POPR	222	MJR	BF
Mixed herbaceous (disturbed) RPT-	WEED	223	MNR	BF
Agrostis stolonifera RPT	AGST	223	MJR	BF-CF
Artificially flooded				
Hay land RPT-	HAY	224	MJR	BF
SUBSTRATE				
Intermittently Flooded				
Silt bar RVT	SIB	100	MJR	CF
Herbaceous silt bar RVT	HSIB	105	MJR	CF
Sand bar RVT	SB	110	MJR	CF
Herbaceous sand bar RVT	HSB	115	MJR	CF
Gravel bar RVT	GB	120	MJR	CF
Herbaceous gravel bar RVT	HGB	125	MJR	CF
Cobble bar RVT	CB	130	MJR	CF
Herbaceous cobble bar RVT	HCB	135	MNR	CF
Eroded bank RVT	EB	150	MJR	CF
Vegetated bank RVT	VB	155	MJR	CF
Slumped bank RVT	SLUMP	160	MNR	CF
MISCELLANEOUS TYPES				
Down woody material MCT	DWM	192	MNR	CF-BF
Mine tailings/overburden MCT	TAIL	195	MNR	BF
Talus MCT	TALUS	196	MNR	BF
Water AQT	WATER	197	MJR	NA
Road MCT	ROAD	199	MJR	BF
Boulder MCT	BD	140	MNR	CF
Bedrock MCT	ROCK	145	MNR	BF-CF

KEY TO PHYSIOGNOMIC CLASSES

1a. Trees and shrubs have a total aerial cover greater than 30 percent.
  2a. Trees are dominant.
    GROUP 1 - FORESTED HABITATS
  2B. Shrubs are dominant.
    GROUP 2 - SHRUB HABITATS

1b. Trees and shrubs have a total aerial cover less than 30 percent.
  3a. Perennial grasses and forbs are dominant, generally with a total canopy cover greater than 60 percent.
    GROUP 3 - HERBACEOUS HABITAT
  3b. Perennial grasses and forbs absent, widely scattered or with a total cover less than 60 percent; substrates are streambars with little or no soil development.
    GROUP 4 - STREAMBAR HABITAT
1c. Other than above.
    GROUP 5 - MISCELLANEOUS HABITAT

KEY TO VEGETATION TYPES

GROUP 1 - FORESTED HABITATS

1a. *Populus tremuloides* dominant in the overstory.
  2a. Shrub and/or herbaceous strata dominated by hydrophytes, often including *Rosa woodsii*, *Salix* spp., *Ribes* spp. and *Poa pratensis*; occurs on floodplains and levees.
    ***Populus tremuloides*/mesic herbaceous RPT**
  2b. Shrub and/or herbaceous strata dominated by upland species; occurs on alluvial fans and residual slopes.
    ***Populus tremuloides*-upland UPT**

herbaceous strata dominated by facultative hydrophytes; occurs on floodplains and levees.
    ***Populus angustifolia*/mesic herbaceous RPT**

1c. *Abies lasiocarpa* dominant in the overstory; shrub and/or herbaceous strata dominated by upland species.
    ***Abies lasiocarpa*-upland UPT**

1d. Other than above.
    Unclassified forested habitat

GROUP 2 - SHRUB HABITATS

1a. *Salix* spp. dominant or codominant in the overstory.
  2a. Substrates are soil, generally with total herbaceous cover greater than 30 percent; bank-forming types.
    3a. *Salix boothii*, S. *lutea*, S. *geyeriana*, and/or S. *drummondiana* dominant or codominant.
      4a. Herbaceous strata is an assemblage of hydric species, such as *Carex nebrascensis*, with relatively low diversity.
        ***Salix* spp./*Carex* spp. RPT**
      4b. Herbaceous strata is a more diverse assemblage of obligate and facultative hydrophytes with grasses dominant in open microsites and forbs dominant under shrub canopies; hydric species such as *Carex nebrascensis* are not dominant.
        ***Salix* spp./mesic herbaceous RPT**
    3b. *Salix exigua* dominant in the overstory.
        ***Salix exigua*/mesic herbaceous RPT**
    3c. *Alnus incana* is dominant or codominant in the overstory; *Populus tremuloides*, *Cornus sericea*, *Ribes* spp., *Prunus virginiana*, *Rosa woodsii* and other *Salix* spp. generally present; herbaceous strata includes obligate and facultative hydrophytes, mostly forbs.
        ***Alnus incana*/mesic herbaceous RPT**
  2b. Substrates are streambars with less than 60 percent herbaceous cover; channel-forming types.
    5a. Surface sediment is mostly gravel.
        ***Salix* spp./gravel bar RVT**
    5b. Surface sediment is mostly cobble.
        ***Salix* spp./ cobble bar RVT**
    5c. Surface is covered by dead branches.
        ***Salix* spp./down woody material RVT**

1b. Overstory dominated by upland shrubs, commonly including *Artemisia tridentata*, *Chrysothamnus viscidiflorus*, *Ribes* spp., *Rosa woodsii* and *Symphoricarpos oreophilus*; herbaceous strata may include both upland and hydrophytic species, mostly grasses; occurs on floodplains in fluvial lands but is transitional to upland habitat.
    Mixed Shrub/grass meadow RPT-

1c. *Artemisia tridentata* and *Chrysothamnus nauseosus* codominant in the shrub stratum; herbaceous stratum is sparse and dominated by upland species; occurs on floodplains in alluvial lands.
    ***Artemisia tridentata* - *Chrysothamnus nauseosus* UPT**

1d. Upland species dominant in both the shrub and herbaceous strata; occurs on alluvial fans, moraines, glacial outwash plains and residual landforms.
    Undifferentiated Upland Shrub UPT

1e. Other than above.
    Unidentified Shrub Habitats

GROUP 3 - HERBACEOUS HABITATS

1a. Aquatic habitat with emergent vegetation; associated with stream margins and beaver ponds.
  2a. *Typha latifolia* or *Scirpus americanus* generally dominant; often associated with beaver ponds.
    Wetland complex AQT
  2b. *Nasturtium officinale* is dominant; occurs near springs and along stream margins.
    ***Nasturtium officinale* AQT**

1b. Semipermanently flooded to saturated habitat; springs and stream margins; hydric species dominant.
  2a. *Carex nebrascensis* is dominant; springs and stream margins.
    ***Carex nebrascensis* RPT**
  2b. *Carex rostrata* is dominant; springs and stream margins.
    ***Carex rostrata* RPT**
  2c. *Mimulus guttatus* generally dominant or codominant; occurs along flowing spring rivulets.
    ***Mimulus guttatus* RPT**
  2d. *Eleocharis palustris* is dominant; occurs in spring areas and along stream margins.
    ***Eleocharis palustris* RPT**

1c. Seasonally, intermittently and artificially flooded habitat; generally on floodplains or alluvial fans.
  4a. *Agrostis stolonifera* is dominant; occurs along stream margins and on floodplains; intermittently flooded.
    ***Agrostis stolonifera* RPT**
  4b. *Poa pratensis* is present, generally with at least 20 percent cover; *Juncus balticus* or *Carex praegracillis* may be codominant; occurs on floodplains; seasonally flooded habitat.
    Poa pratensis RPT
  4c. A diverse assemblage of "weedy" vegetation, commonly including *Circium* spp., *Urtica dioca*, *Rosa woodsii* and *Ribes* spp.; occurs on sediments recently deposited by stream flooding.
    Mixed herbaceous (disturbed) RPT-
  4d. Artificially flooded land used as pasture and cut for hay.
    Hay land RPT-

1d. Other than above.
    Unclassified herbaceous habitat

GROUP 4 - STREAMBAR HABITATS

1a. Vegetation cover is less than 30 percent; occurs within the stream channel.
  2a. Surface sediment is mostly silt.
    Silt bar RVT
  2b. Surface sediment is mostly sand.
    Sand bar RVT
  2c. Surface sediment is mostly gravel.
    Gravel bar RVT
  2d. Surface sediment is mostly cobble.
    Cobble bar RVT
  2g. Eroded Bank.
    Eroded bank RVT
  2h. Detached portion of streambank.
    Slumped bank RVT

1b. Vegetation cover is less than 60 percent; occurs within the stream channel.
  3a. Surface sediment is mostly silt.
    Herbaceous silt bar RVT
  3b. Surface sediment is mostly sand.
    Herbaceous sand bar RVT
  3b. Surface is mostly gravel.
    Herbaceous gravel bar RVT
  3c. Surface is mostly cobble.
    Herbaceous cobble bar RVT
  3d. Healed form of eroded bank; vegetation sufficient to stabilize bank.
    Herbaceous bank RVT

1c. Other than described.
  Unidentified streambar habitat

GROUP 5 - MISCELLANEOUS HABITATS

1a. Surface covered by a mat of dead branches.
  Down woody material MCT
1b. Mine tailings and overburden.
  Tailing MCT
1c. Talus slopes.
  Talus MCT
1d. Water.
  Water AQT
1e. Roads.
  Road MCT
1f. Boulder.
  Boulder MCT
1g. Consolidated bedrock.
  Bedrock MCT
1f. Other than above.
  Unidentified miscellaneous habitat

5.0 ASSESSMENT OF RIVERINE/RIPARIAN HABITAT

A method for assessing the condition of RRH relative to its natural or achievable state (potential) was developed, in part, through preliminary studies in control (rested) and treatment (grazed) pastures of six livestock/fishery study areas (LFSAs) in Nevada and Utah (Platts et al. 1988a; 1988b). These preliminary studies (summarized in sections 5.1 and 5.2) are of limited value for assessing condition, but lay the groundwork for development of a more comprehensive approach.

The pilot study enlarged the scope from LFSAs (generally less than 5 acres including about 0.4 miles of stream course) to the target watershed (about 597 square miles including 1,654 miles of stream course). Further studies may improve application of the more comprehensive method (discussed in Section 5.3), yet it shows promise as a general approach for assessing condition.

Relationships between assessments and vegetation types are evaluated in Section 5.4. Relationships between assessments and trout populations are discussed in Section 5.5.

5.1 Width of Streambars as Affected by Grazing

The impacts of livestock upon the widths of streambars in four LFSAs in Nevada and two LFSAs in Utah were assessed in this preliminary study. Field work was conducted during 1986 and 1987 and reported in 1988 (Platts et al. 1988a; 1988b).

Each LFSA consisted of 3 or 4 stations. Stations included either 60 transects perpendicular to streamflow at 10 foot intervals (Tabor, Gance, Lower Big Creek and Upper Big Creek LFSAs) or 20 transects at 30 foot intervals (Deer and Cottonwood LFSAs), along which stream, channel and riparian attributes were measured. The width of streambars and eroded

banks (as identified in Section 4.7) were measured along each transect between the edge of the stream and the top of streambanks. Bank-forming vegetation types were also identified.

Treatments, ranging from seasonal grazing to 18 years of rest, and valley-bottom types for each LFSA are listed in Table 5.1-1.

Table 5.1-1. Valley-bottom type (VBT) and treatments of stations for LFSAs in Nevada and Utah.

Station	Code	VBT (1)	Treatment
TABOR 1	TB01	1220	Summer grazing
TABOR 2	TB02	1220	Rested since 1982
TABOR 3	TB03	1220	Rest-rotation since 1982
GANCE 1	GZSA1	1220	Summer grazing
GANCE 2	GZSA2	1220	Rested since 1982
GANCE 3	GZSA3	1220	Summer grazing
LOWER BIG CREEK 1	LBC01	1220	Summer grazing
LOWER BIG CREEK 2 *	LBC02	1220	Rested since 1970
LOWER BIG CREEK 3	LBC03	1220	Summer grazing
UPPER BIG CREEK 1	UBC01	1220	Summer grazing
UPPER BIG CREEK 2	UBC02	1220	Rested since 1982
UPPER BIG CREEK 3	UBC03	1220	Rested since 1982
UPPER BIG CREEK 4	UBC04	1220	Summer grazing
DEER 1	DR01	2260	Summer grazing
DEER 2 *	DR02	2260	Rested since 1981
DEER 3	DR03	2260	Summer grazing
COTTONWOOD 1	CT01	3310	Summer grazing
COTTONWOOD 2	CT02	3310	Rested since 1985
COTTONWOOD 3	CT03	3310	Summer grazing

(*) denotes preliminary reference stations
(1) 1220 = sedimentary/fluvial/V-shaped depositional;
2260 = volcanic/fluvial/notch-shaped depositional;
3310 = tuffaceous/alluvial/confined floodplain;

Differences in the widths of streambars were apparent between rested and grazed pastures of some LFSAs. Statistical procedures were used to test for these differences. The mean width of streambars was lower in the rested versus grazed pasture of the Gance LFSA. Results for other stations were obscured by conditions prior to exclosure, the short period of rest and inherent differences between control and treatment pastures.

These results were refined by looking at the widths of specific types of streambars (e.g. gravelbars versus herbaceous sandbars). The widths of streambar types for grazed versus rested treatments of four stations in northern Nevada are illustrated in Figure 5.1-1. In rested pastures, the trend is a decrease in gravel bars (GB) and eroded banks (EB), and an increase in the extent of herbaceous gravelbars (HGB), sandbars (SB) and herbaceous sandbars (HSB), compared to grazed pastures. Deposition of sand and stabilization of substrates by vegetation may reflect the mechanism of restoration in rested pastures. Contradictions to this trend in the Cottonwood LFSA were attributed to differences before exclosures were built and to the short period of rest. The frequency of eroded banks in the rested pasture of the Gance LFSA was attributed to the inherent instability of the residual slope that flanks one side of the channel. It was hypothesized that stratification by landform could be used to account for this variance.

The extent of streambar types for two LFSAs along Big Creek in northern Utah are illustrated in Figure 5.1-2. Trends similar to those of the Nevada LFSAs are apparent for the Upper Big Creek study area that had been rested for about five years. In the Lower Big Creek LFSA, rested for 18 years, streambars have been replaced by stable, bank-forming vegetation types.

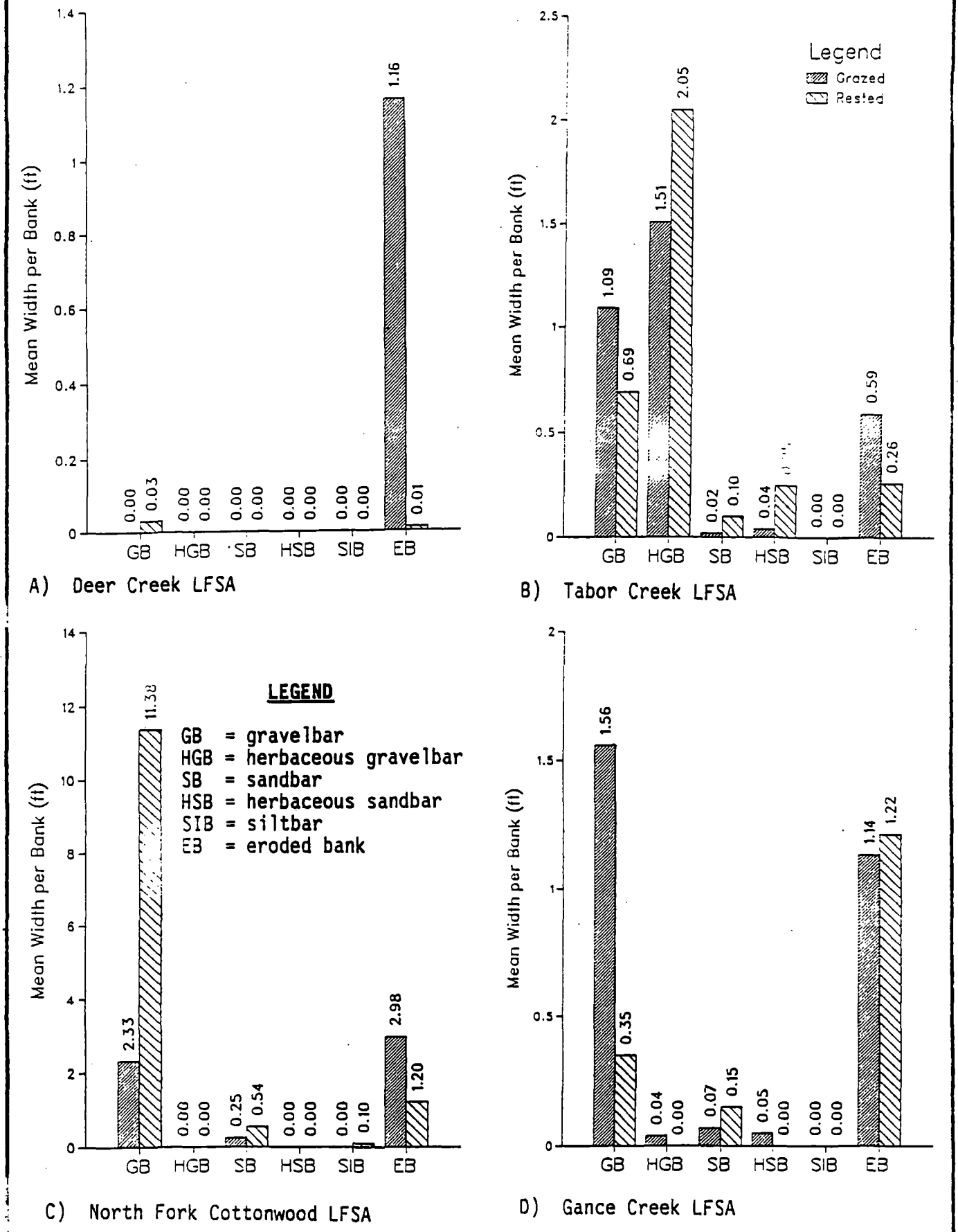
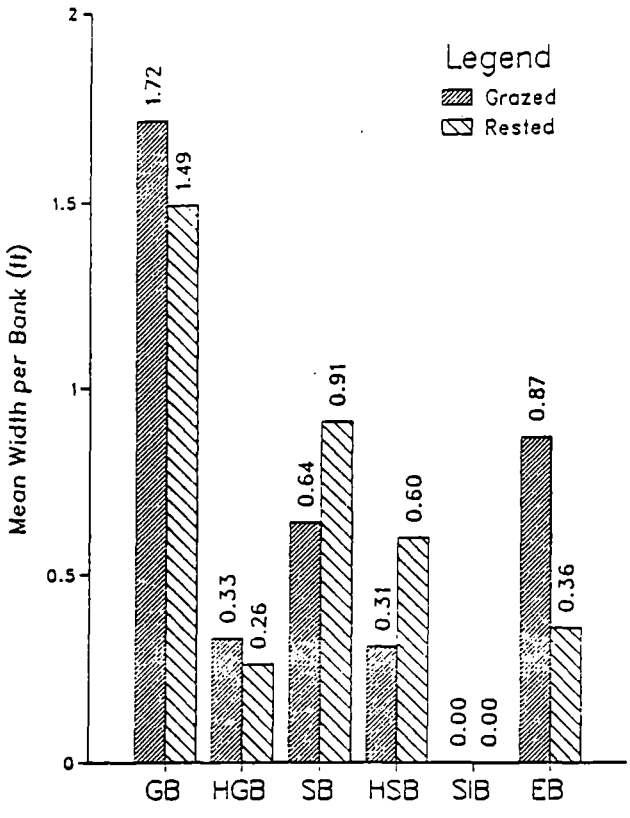
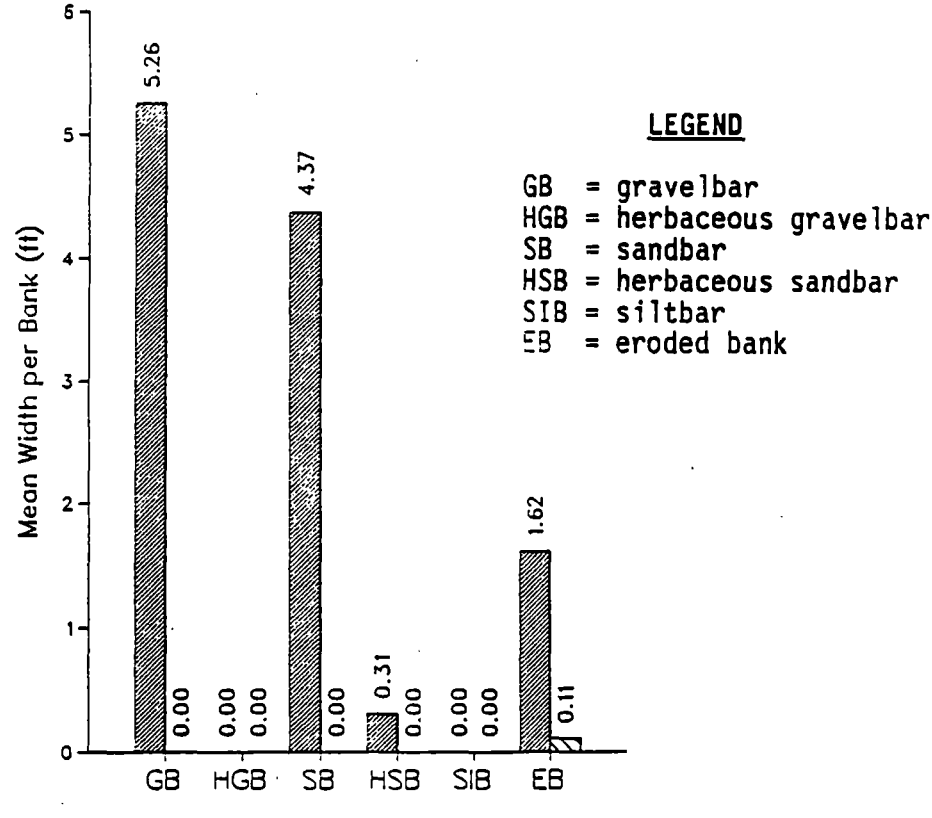


Figure 5.1-1. Mean widths of RVTs measured in grazed and rested pasures of four LFSAs in northern Nevada.



A) Upper Big Creek LFSA



B) Lower Big Creek LFSA

Figure 5.1-2. Mean widths of RVTs measured in grazed and rested pastures of two LFSAs in northern Utah.

Observations also indicated that drier bank-forming vegetation types were associated with more extensive eroded banks and streambars. For each LFSA, one-way AOV was conducted for bank-forming vegetation types that were identified on at least five transects. Separate AOVs were conducted for grazed and rested treatments. Significant differences between at least two vegetation types were found for all tests except grazed stations on Deer Creek and rested stations on Gance Creek (see Table 5.1-2). For all LFSAs there is a general trend toward greater average width of streambars and eroded banks for the drier bank-forming vegetation types. This was consistent for both grazed and rested pastures. The greater widths for the POPR vegetation type in grazed pastures was attributed to livestock concentration.

These analyses indicated significant differences in the widths of streambars and eroded banks between treatments for one LFSA and for some bank-forming vegetation types. Trends in the widths of specific streambar types were also observed between grazed and rested pastures. While results were useful for conceptual development, they required intensive monitoring in control and treatment pastures and were of limited use for assessing the condition; also, they could not be extrapolated to other areas. Subsequent studies entailed evaluation of more comprehensive stream, riparian and channel attributes for RRH of more-homogeneous potential.

Table 5.1-2. Mean width of streambars and eroded banks for various bank-forming vegetation types (results of F-tests); the order of vegetation types listed for each treatment is from wet to dry.

LFSA TREATMENT BANK-FORMING TYPE	N	MEAN WIDTH (feet)
Deer Creek		
GRAZED ($p > .05$)		
CARO	12	0.0a
POPR	25	2.0a
POTR/MH	19	1.7a
POTR-UP	21	1.0a
RESTED ($p < .05$)		
CARO	18	0.0a
POPR	25	0.8b
POTR/MH	30	0.8b
North Fork Cottonwood		
Grazed ($p < .05$)		
POPR	16	5.9a
SALIX/MH	35	5.0a
ARTR-UP	18	8.6b
Rested ($p < .001$)		
POPR	14	4.3a
SALIX/MH	19	14.7b
ARTR-UP	34	14.2b
Tabor Creek		
Grazed ($p < .001$)		
CANE	12	0.0a
JUBA	41	2.0ab
POPR	33	3.4bc
SALIX/DWM	31	1.7a
SALIX/MH	24	4.3cd
ARTR/POPR	40	5.2d
ARTR-UP	31	5.0d
Rested ($p < .001$)		
JUBA	14	1.8a
POPR	46	1.6a
SALIX/DWM	15	0.3a
SALIX/MH	10	1.6a
ARTR/POPR	10	12.2b
ARTR-UP	16	7.3b

* Mean widths for a LFSA and treatment followed by a same letter are not significantly different;
JUBA was later combined with the POPR RPT.

Table 5.1-2. (Continued)

LFSA TREATMENT BANK-FORMING TYPE	N	MEAN WIDTH (feet)
Gance Creek		
Grazed ($p < .001$)		
POPR	49	5.0c
SALIX/DWM	9	0.0a
SALIX/MH	99	3.2b
ARTR/POPR	41	3.4bc
UPLAND SHRUB	14	4.0a
Rested ($p > .05$)		
POPR	8	2.5a
SALIX/MH	69	2.2a
ARTR/POPR	19	1.6a
UPLAND SHRUB	14	4.0a

5.2 Assessment Relative to Reference Stations

An attempt was made to rate the condition of stations in LFSAs relative to a control or reference station. A set of 35 stream, riparian and channel attributes measured in the six LFSAs were selected for analyses. Mean values of attributes for stations of each LFSA are tabulated in APPENDIX H. Preliminary reference stations, selected according to management history and apparent state of restoration, were also identified.

One-way AOV was used to test for differences between reference and treatment stations for each of the 35 attributes. Attributes for which the reference stations were consistently higher or lower than treatment stations and the number of treatment stations that were significantly different from the reference station are listed in Table 5.2-1.

Table 5.2-1. Attributes measured in LFSAs that were used to compare control and treatment stations. Attributes for which the control station value was higher or lower than treatment stations have a number that indicates how many treatment stations were significantly different from the control.

Attribute	Number of Stations Different than Control 1220 VBT (out of 12)	2260 VBT (out of 2)
Mean width of channel forming types	11	1
Percent of banks with channel-forming types	11	-
Mean width of eroded banks	6	1
Percent of banks that are eroded	9	1
Stream width / stream depth	12	-
Channel width / stream depth	12	-
Stream width	-	0
Stream depth	12	-
Stream width * stream depth	-	-
Mean pool width	11	-
Mean riffle width	9	-
Percent of width that is pool	12	-
Pool rating	12	1
Pool feature	8	0
Average bank angle	12	1
Average bank undercut	12	1
Average bank water depth	12	2
Boulder--width of stream	-	-
Boulder--percent of width	-	-
Rubble--width of stream	9	0
Rubble--percent of width	10	0
Gravel--width of stream	9	1
Gravel--percent of width	12	1
Fines (0.18-0.033")--width of stream	6	2
Fines (0.018-0.033")--percent of stream	4	2
Fines (<0.033")--width of stream	-	1
Fines (<0.033")--percent of stream	-	-
Total fines--width of stream	-	1
Total fines--percent of stream	9	1
Percent Embeddedness	-	1
Instream vegetation cover--width	-	-
Average stability (percent)	12	2
Total alterations (percent)	11	2
Stream cover (rating)	7	0
Vegetation overhang	-	2

For the 1220 VBT (sedimentary/fluvial/V-shaped depositional), 24 attributes measured in the preliminary reference station (designated as LBC02) were significantly different from those measured in half or more of the treatment stations; 10 attributes were significantly different from all treatment stations.

For the 2260 VBT (volcanic/fluvial/notch-shaped depositional), 18 attributes were significantly different between the preliminary reference station (designated as DR02) and half of the treatment stations (only 2 treatment stations were represented); 6 attributes were significantly different from both treatment stations.

Assuming that preliminary reference stations represent endpoints of restoration (i.e. achievable states), attributes most different from those of treatment stations may be the most sensitive to livestock impacts. These included measures of streamflow (width/depth ratio, percent pools, pool rating, bank water depth), channel substrates (percent of rubble, gravel and fines), channel structure (width of streambars, width of eroded banks, frequency of eroded banks, channel width/stream depth, bank angle, depth of undercut, bank stability) and riparian habitat (stream cover).

Additional analyses were conducted to evaluate hypotheses of differences between reference and treatment stations classified to the level of **landform** (residual, alluvial, floodplain and levee). Tests for differences in four attributes between different landforms within the same LFSA were conducted. The four attributes selected for this analysis were width of streambars and eroded banks, width of eroded banks, frequency of banks associated with streambars and eroded banks, and frequency of unstable (eroding) banks. These attributes were selected to reflect the relative erodibility of banks for contrasting landforms and their sensitivity to

livestock impacts. Results of these analyses are presented in Table 5.2-2.

In nearly all cases, residual landforms were associated with the greatest width of streambars and eroded banks. Alluvial landforms were also associated with greater widths than floodplains or levees. In addition, the coefficient of variation (standard deviation divided by the mean) was less for residual and alluvial landforms. Higher and drier streambanks are less stable and are associated with wider streambars and eroded banks. Results indicated that classification of stations to the level of landforms could be used to refine assessment of impacts, at least for the four attributes considered in this analysis.

Table 5.2-2. Means (± std. dev.) of four attributes measured within four landforms of LFSAs; estimates include a minimum of 10 samples.

LFSA	Attribute Code (1)	LANDFORM TYPES Residual	Alluvial	Floodplain	Levee
UBC-1	1	---	9.45 + 7.45	3.84 + 5.27	---
UBC-3	1	---	---	4.20 + 6.27	4.77 + 4.77
Tabor-1	1	---	4.93 + 4.30	2.72 + 5.23	3.35 + 6.86
Tabor-2	1	---	7.31 + 8.67	3.15 + 6.91	1.00 + 1.87
Tabor-3	1	---	5.00 + 4.77	3.67 + 5.46	1.96 + 3.85
Gance-1	1	---	---	4.07 + 4.13	4.84 + 6.02
Gance-2	1	4.00 + 2.94	---	1.85 + 2.53	2.01 + 3.00
Gance-3	1	6.54 + 4.25	---	4.59 + 3.14	2.33 + 3.98
UBC-1	2	---	81.8 + 40.4	59.1 + 49.4	---
UBC-3	2	---	---	46.7 + 50.1	20.0 + 42.2
Tabor-1	2	---	80.0 + 41.4	35.1 + 48.1	29.0 + 46.1
Tabor-2	2	---	81.3 + 40.3	31.4 + 46.8	24.0 + 43.6
Tabor-3	2	---	62.5 + 50.0	52.1 + 50.3	33.3 + 48.2
Gance-1	2	---	---	73.7 + 44.4	70.7 + 45.9
Gance-2	2	78.7 + 42.6	---	46.2 + 50.8	39.0 + 49.1
Gance-3	2	87.5 + 33.8	---	91.2 + 28.8	33.3 + 47.5
Tabor-1	3	---	4.40 + 4.01	0.33 + 1.19	0.26 + 1.03
Tabor-2	3	---	0.82 + 1.05	0.19 + 0.64	0.24 + 0.83
Tabor-3	3	---	1.25 + 1.73	0.42 + 1.03	0.00 + 0.00
Gance-1	3	---	---	0.72 + 1.25	0.31 + 0.92
Gance-2	3	3.57 + 3.11	---	1.58 + 2.42	0.64 + 1.65
Gance-3	3	5.46 + 3.67	---	1.58 + 1.67	0.55 + 1.56
Tabor-1	4	---	80.0 + 41.4	8.8 + 28.5	6.4 + 25.0
Tabor-2	4	---	43.8 + 51.2	8.6 + 28.2	8.0 + 27.7
Tabor-3	4	---	43.8 + 51.2	15.9 + 36.9	0.0 + 0.0
Gance-1	4	---	---	31.6 + 46.9	12.1 + 32.9
Gance-2	4	71.4 + 46.9	---	42.3 + 50.4	16.9 + 37.7
Gance-3	4	83.3 + 38.1	---	55.9 + 50.4	13.3 + 34.3
Deer-1	1	---	0.23 + 0.45	0.87 + 1.00	---
Deer-1	2	---	23.5 + 43.7	47.8 + 51.1	---
Deer-1	3	---	0.41 + 0.87	2.78 + 4.13	---
Deer-1	4	---	23.5 + 43.7	43.5 + 50.7	---
NFC-2	1	---	14.2 + 10.9	3.33 + 4.40	14.7 + 13.1
NFC-3	1	---	8.80 + 7.40	1.70 + 3.09	1.80 + 3.71
NFC-2	2	---	94.1 + 23.9	61.1 + 50.2	79.0 + 41.9
NFC-3	2	---	93.8 + 25.0	50.0 + 52.7	40.0 + 51.6
NFC-2	3	---	2.71 + 3.22	0.11 + 0.32	0.11 + 0.46
NFC-3	3	---	2.81 + 2.43	0.70 + 1.06	0.20 + 0.63
NFC-2	4	---	61.8 + 49.3	11.1 + 32.3	5.3 + 22.9
NFC-3	4	---	62.5 + 50.0	40.0 + 51.6	10.0 + 31.6

(1) Attribute Codes:
1 = Width of streambars and eroded banks (feet); 2 = Percent of banks with streambars and eroded banks; 3 = Width of eroded banks (feet); 4 = Percent of banks that are eroded

Fifteen attributes were selected for development of a simple model to rate the condition of treatment stations. These attributes were chosen as they showed significant differences between many (or all) of the treatment sites and reference sites and thus may be sensitive to livestock grazing. Inputs for the condition model are listed below.

1. Average total width of streambars and eroded banks
2. Percent of banks that were eroded
3. Stream width/stream depth
4. Channel width/stream depth
5. Pool width/stream width
6. Pool rating
7. Average bank angle
8. Average bank undercut
9. Average bank water depth
10. Rubble--percent width
11. Gravel--percent width
12. Fines--percent width
13. Average bank stability
14. Total bank alteration
15. Stream cover (rating)

The simple model for assessing condition calculates the difference in measurements between treatment stations and reference stations, using the sum of the absolute value of normal scores for each attribute. In statistical terms, the normal score for an attribute is the mean for the treatment station minus the mean for the reference station divided by the standard deviation of the reference station. A score near zero means the attribute in a treatment site is nearly identical to the reference site. The closer the sum of normal scores for all attributes to zero, the more the treatment station resembles the reference.

Condition classes, based on the normal score (<10 = excellent; 10 to 20 = good; 20 to 30 = fair; > 30 = poor) were assigned for the 1220 VBT. Condition classes were not assigned for the 2260 VBT since too few treatment stations were measured to get a feel for the range. The Cottonwood LFSA was not considered since an appropriate reference station has not been

identified for the 3310 VBT. Results of this simple model are presented in Table 5.2-3. The ranking of stations generally corresponds with qualitative observations of condition and impact. Rested stations generally ranked higher than grazed stations.

Table 5.2-3. Assessments of LFSA stations, relative to preliminary reference stations.

VBT	Rank	Station	Score	Condition	Treatment
1120	1	LBC02	0.0	REFERENCE	Rested since 1970
1120	2	UBC02	19.5	GOOD	Rested since 1982
1120	3	UBC04	19.6	GOOD	Rest-rotation
1120	4	TABOR-2	20.0	GOOD	Rested since 1982
1120	5	TABOR-3	21.9	FAIR	Rest-rotation
1120	6	UBC02	24.6	FAIR	Rested since 1982
1120	7	TABOR-1	24.9	FAIR	Summer grazing
1120	8	GANCE-2	27.7	FAIR	Rested since 1982
1120	9	LBC03	29.4	FAIR	Summer grazing
1120	10	GANCE-1	21.7	FAIR	Summer grazing
1120	11	GANCE-3	33.0	POOR	Impacted by culvert
1120	12	UBC01	33.0	POOR	Summer grazing
1120	13	LBC-1	41.4	POOR	Summer grazing
2160	1	DEER-2	0.0	REFERENCE	Rested since 1978
2160	2	DEER-3	15.6	----	Summer grazing
2160	3	DEER-1	18.9	----	Summer grazing

These assessments of condition were viewed with reservation, since the difference in the distribution of landforms between stations was not considered. Suggested refinements of these assessments entail calculating the normal scores for each bank-forming landform (i.e. residual, alluvial, levee and floodplain) that occurs within a station or calculating normal scores for the landform (e.g. floodplain) that is most sensitive to nps impacts. The reason the Gance-2 station, rested since 1982, ranked only fair condition relative to the reference is that it is flanked by alluvial and residual landforms that are inherently more unstable than the floodplains and

levees typical of the control station. The UBC-2 station, which ranked fair, was impacted by channel downcutting and headcutting originating in UBC-1, located immediately downstream.

Another serious limitation to these assessments is the representative quality of reference stations: pristine sites for reference stations may not be available for some valley-bottom types. Management may also alter the state achievable through restoration. For example, instream structures in LBC-2 have undoubtedly influenced the potential endpoint of restoration by increasing the average water surface elevation, bank water storage and bank-forming vegetation. Thus, the relative rankings and normal scores of treatment stations should be adjusted according to measurements taken in a more representative reference station. To overcome these disadvantages, an alternative approach was designed to assess the condition of RRH by reference to a progression of states.

5.3 Assessment Relative to a Progression of States

This approach to assessment compares the existing state of RRH to a progression of states, ranging from natural to severely impacted. Viewed as a stream cross-section (i.e. transect), two progressions were recognized: 1) that leading to an increase in channel depth (incised channel), often with a corresponding increase in channel width; and 2) that leading to an increase in channel width with little change in channel depth (overbroadened channel). Hypothetical progressions were developed from field observations and were evaluated through independent analyses of stream, channel and riparian attributes measured along transects in survey stations.

The former progression is a common response to nps impacts where channel substrate is more erodible than the streambanks. Channel incision is a prevalent response to impacts in fluvial lands (1210, 1220, 2220 and 2260

VBTs) and in alluvial lands (2310, 3310 and 3320 VBTs) in the target watershed. It is also prevalent in fluvial lands (3210 and 3220 VBTs) that are not represented in the target watershed but were sampled nearby in Coal Mine Canyon.

The latter progression results where channel substrate is less erodible than streambank materials. Impacts result in receding streambanks, overbroadened channels and braided streams, with little change in channel depth. This progression is a common response in glacial lands (1110, 1120 and 1130 VBTs) where substrates are mostly rubble and boulders and in erosional (notch-shaped) canyons (1250 VBT) where channel substrate is typically consolidated.

A hypothetical progression of states leading to an incised channel is illustrated in Figure 5.3-1. The natural state (5.3-1A) is characterized by hydric, bank-forming vegetation types; stable, overhanging streambanks; a "fit" channel that overflows to dissipate the power of peak runoff over floodplains and levees; and ground water level within the rooting depth of riparian vegetation on floodplains and levees.

Initial impacts of livestock grazing (5.3-1B) include: damage to streambanks; replacement of hydric bank-forming vegetation types with streambars or more mesic vegetation types; and subtle lowering of stream and associated groundwater levels, allowing encroachment of upland vegetation onto floodplains. These alterations represent a critical state, beyond which impacts lead to incision of the stream channel.

Incised channels (5.3-1C) exhibit a decrease in stream sinuosity; significant lowering of stream and groundwater levels; and replacement of riparian vegetation by upland plants. The higher and drier streambanks are more prone to failure, leading to broadening of the channel (5.3-1D).

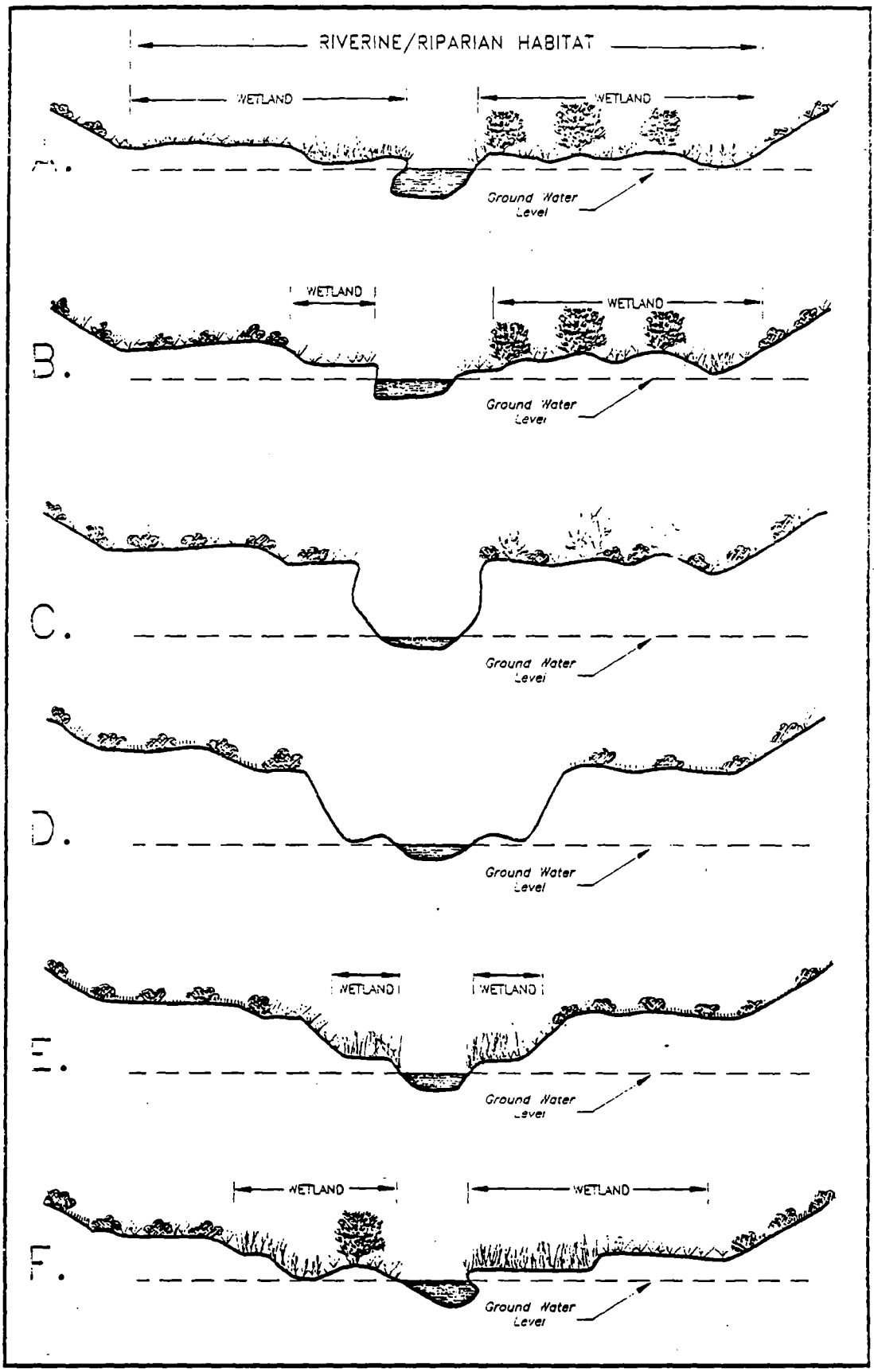


Figure 5.3-1. Progression of states leading to an incised channel (1220 VBT): A) natural; B) damaged streambanks (critical state) C) incised channel; D) failed banks; E) stabilization and aggradation; F) achievable state.

Given rest, vegetation stabilizes the wetted channel bottom, encouraging deposition of sediments and a rise in stream and groundwater levels (5.3-1E). Continued aggradation and stabilization eventually leads to an achievable state (5.3-1F) that is similar to the natural state, although usually at a lower base-level. Harvey et al. (1985) describe a similar evolution of states for all incised channels.

A hypothetical progression of states for overbroadened channels was developed based on observations in glacial lands (1110, 1120 and 1130 VBTs), where substrates are primarily rubble and boulders. In the natural state, vegetated streambanks confine the stream and maintain a deep water-column. Initial impacts of livestock grazing result in deterioration of streambanks and enlargement of streambars. The shallower and more dispersed streamflow is more prone to formation of anchor ice, causing channels to shift and braid across the bottom. Continued erosion of topsoil leads to elimination of herbaceous vegetation. In glacial trains (1120 VBT), groundwater levels and existing woody vegetation were little affected although root crowns of trees and shrubs were often exposed above the ground surface. In glacial basins (1110 VBT) the dispersed streamflow may result in greater evaporative losses while in areas of glacial outwash (1130 VBT) type the dispersed streamflow probably results in greater bedloss and a trend towards intermittent streamflow. Restoration entails deposition of fine sediments, reestablishment of herbaceous vegetation and creation of a more confined stream channel.

A segment of stream will include a variety of states (see Figure 5.3-1). Streams in good condition should include many cross-sections that are similar to state A, a few like state B and maybe one or two like state C. For a moderately impacted stream, most cross-sections will resemble state B,

with a few like A, C and D. Cross-sections of a severely impacted stream will mostly resemble D, with a few similar to state C. The distribution of states also may be used for inferring trend. For a stream in good condition, a few cross sections in state C or D may forecast deterioration under current management.

Assessments of condition relative to a progression of states were first developed for flowing streams (section 5.3.1) using both stream and channel attributes. Assessments for intermittent (dry) streams (section 5.3.2) were developed from channel attributes. Assessments based on a subset of attributes measured in General Aquatic Wildlife Surveys (GAWS) were evaluated in section 5.3.3.

5.3.1 Condition Ratings for Flowing Streams

Discriminant functions were used to calculate a **score** for each transect from measurements of stream and channel attributes. The **condition rating** was the average score for transects in each survey station. Condition ratings can be related to the progression of states (see Figure 5.3-1) and the effects of subsequent impacts and/or alternative management can be projected.

Discriminant functions are linear combinations of several variables that are used to predict the class of an entity. In this study, stream and channel attributes were used to predict a score for each transect. Discriminant functions are developed using a set of objects whose classification is known. Rather than subjectively assigning classes to a set of transects for developing discriminant functions, **cluster analysis** was used to group transects based upon similarities in stream and channel attributes.

Transects in non-glacial valley-bottom types were clustered into four groups using an algorithm in the NCSS statistical software package (Hintze 1987). The means of attributes within each of the 4 groups were then used to assign the appropriate state to the set of transects in a group. These transects of known state were used to develop discriminant functions, from which the state of other transects could be predicted. Condition ratings for stations were calculated from both the cluster ratings and the discriminant functions. Assuming that the ratings derived from the clustering of transects was "correct", the accuracy of the discriminant functions could be evaluated by comparing the condition ratings derived from the two analyses.

Ratings were first developed for 42 stations located in fluvial (1210 and 1220) valley-bottom types. These stations included a range of grazing treatments from long-term rest to long-term intensive grazing. **Only tran-**

sects with levee or floodplain on both sides of the channel were selected to eliminate the variance associated with contrasting bank-forming landforms. Eleven attributes were used to characterize each transect (Table 5.3-1). These attributes were selected as being relatively independent of stream size, reliably measurable and likely to be sensitive to nps impacts.

A test for consistancy, entailing two cluster analyses, was performed. Half of the stations in the 1210 and 1220 VBTs were randomly selected for one analysis (Set 1) while the remaining were used for the other analysis (Set 2). If the characteristics of these groups were consistent for the two sets, then the two clusterings should result in similarities in mean attributes within groups (A through D).

Table 5.3-1. Attributes used to assess transects and results of preliminary clustering of two randomly selected sets of stations in the 1210 and 1220 VBTs.

No.	Attribute	Attribute Value Set 1 A	Set 1 B	Set 1 C	Set 1 D	Set 2 A	Set 2 B	Set 2 C	Set 2 D
1	% of banks eroded or with bars	46.8	34.7	88.7	95.8	51.8	43.9	95.7	100.
2	% of banks eroded	10.9	4.8	49.6	54.2	6.4	4.5	53.6	64.7
3	Bank angle (deg)	87	131	138	144	79	115	136	144
4	Bank undercut (ft)	0.73	0.09	0.08	0.08	0.79	0.16	0.07	0.06
5	Bank water depth (ft)	0.47	0.05	0.04	0.00	0.64	0.11	0.06	0.01
6	Bank stability (rating)	65	61	34	18	68	63	29	25
7	Depth of channel (ft)	1.8	1.2	3.0	4.0	1.9	1.9	2.9	7.3
8	Channel width/depth	7.49	7.76	7.42	5.50	9.43	7.19	10.1	3.61
9	Stream width/depth	11.7	15.3	19.7	16.5	8.9	14.8	15.8	14.3
10	Channel width/stream width	1.64	1.51	2.67	9.89	1.70	1.79	2.76	6.15
11	Area of channel/area of stream	5.8	6.7	35.5	418.	4.9	15.2	29.5	256.

Mean values for attributes (Table 5.3-1) characterized the states illustrated in Figure 5.3-1 quite well, despite being independently derived. Mean values for Set 1 were also similar to Set 2, indicating relatively consistent clustering between the sets. Clustering into more or fewer than four groups resulted in less satisfactory results.

The state identified for each transect (A, B, C or D) was transformed to a numeric **score** (1, 2, 3, or 4), ordered from best (1) to worst (4). **Condition ratings** for each station were calculated by averaging the scores of transects. States E and F (see Figure 5.3-1) are similar to B and A, respectively, and were assigned scores of 2 and 1.

Discriminant functions were developed for each set, and were used to rate transects within respective sets. Of the 356 transects in Set 1, discriminant functions predicted the correct (same as clustering) score for 95.9 percent of the transects; 95.5 percent of the transects were correctly predicted in Set 2. Condition ratings of survey stations calculated from clustering were also very similar to those calculated from discriminant functions (see Table 5.3-2 and 5.3-3). This indicated that the clustering procedure successfully arranged transects into four discernible groups from which accurate discriminant functions could be developed.

For further validation, the discriminant function developed for set 1 was used to rate stations in Set 2 and that developed for set 2 was used to rate stations in Set 1. Between the two sets, 38 of the 42 ratings calculated using the discriminant function from the other set were within 0.2 of those calculated by clustering and all were within 0.5. This suggested very similar clustering between the two sets; it also showed that discriminant functions accurately predicted the condition of stations in 1210 and 1220 valley-bottom types.

Table 5.3-2. Condition ratings for 21 stations in Set 1 selected from 1210 and 1220 VBTs; ratings were developed from clustering of Set 1, discriminant function from Set 1, and discriminant function from Set 2; the differences in ratings derived from the discriminant functions and the cluster ratings are also shown.

Site	N	Clus. Rating	Discriminant Set 1 Rating	Diff.	Discriminant Set 2 Rating	Diff.
GZ06	10	2.00	2.00	0.00	2.00	0.00
GZ-WM	14	2.71	2.64	0.07	2.79	-0.07
GZSA1	42	2.17	2.19	-0.02	2.14	0.02
GZSA3	24	2.38	2.38	0.00	2.38	0.00
MH05A	6	3.50	3.50	0.00	3.83	-0.33
NF10	17	2.71	2.71	0.00	2.71	0.00
NF13	12	3.00	3.00	0.00	2.75	0.25
PI07	17	1.76	1.88	-0.12	2.00	-0.23
ST03	12	2.58	2.75	-0.17	2.75	-0.16
TR02	17	1.88	1.82	0.06	1.94	-0.06
UBC02	15	2.53	2.53	0.00	2.33	0.20
UBC04	18	2.50	2.44	0.06	2.56	-0.06
WT01	16	1.44	1.50	-0.06	1.62	-0.19
WT02	15	1.40	1.40	0.00	1.47	-0.07
WT03	20	1.90	2.05	-0.15	2.15	-0.25
LBC01	18	2.89	2.89	0.00	3.00	-0.11
TB02	21	2.00	2.00	0.00	2.00	0.00
TB04	19	1.83	1.89	-0.06	2.10	-0.27
TB05	15	2.00	1.93	0.07	2.13	-0.13
TB06	14	2.14	2.21	-0.07	2.29	-0.14
TB11	15	3.07	2.93	0.13	2.93	0.13

Table 5.3-3. Condition ratings for 21 stations in Set 2 from 1210 and 1220 VBTs; ratings were developed from clustering of Set 2, discriminant function from Set 2, and discriminant function from Set 1; differences between ratings derived from the discriminant functions and the cluster ratings are also shown.

Site	N	Clus. Rating	Discriminant Set 2 Rating	Diff.	Discriminant Set 1 Rating	Diff.
GZ05	19	3.47	3.42	0.05	3.00	0.47
GZSA2	23	1.96	2.09	-0.13	1.91	0.04
NF08	13	2.62	2.61	0.00	2.62	0.00
NF09	17	2.76	2.76	0.00	2.76	0.00
NF11	13	2.77	2.77	0.00	2.62	0.15
NF12	20	2.90	2.85	0.05	2.90	0.00
PI06	17	4.00	3.94	0.06	3.76	0.24
ST04	12	2.25	2.25	0.00	2.25	0.00
WN06	5	2.20	2.20	0.00	2.40	-0.20
TR01	19	1.52	1.58	-0.06	1.47	0.05
UBC01	12	3.00	3.00	0.00	3.00	0.00
UBC03	18	1.78	1.72	0.06	1.72	0.06
WT04	19	1.95	2.05	-0.11	1.95	0.00
LBC02	17	1.41	1.47	-0.06	1.35	0.06
LBC03	20	2.50	2.50	0.00	2.00	0.50
TB03	22	2.68	2.68	0.00	2.64	0.04
TB07	21	2.67	2.57	0.10	2.62	0.05
TB07A	16	2.19	2.19	0.00	2.12	0.06
TB08	17	2.41	2.41	0.00	2.29	0.11
TB09	14	2.93	2.93	0.00	2.71	0.21
TB10	6	2.17	2.17	0.00	2.17	0.00

Following these tests, clustering was conducted using all 42 stations in the 1210 and 1220 VBTs. Condition ratings for the 42 stations from this cluster (Table 5.3-4) were very similar to those calculated from clustering of the two sets (Tables 5.3-2 and 5.2-3). Ratings calculated using clustering and the discriminant function were also very similar. Methods for derivation of discriminant functions from dry channel and GAWS attributes are discussed in Sections 5.3-2 and 5.3-3, respectively.

Table 5.3-4. Condition rating for 42 stations in 1210 and 1220 VBTs determined from clustering and discriminant functions using 11 attributes, dry channel attributes and GAWS attributes.

Site	N	Clus. Rating	Disc. (11) Rating	Disc. (11) Diff.	Disc. (Dry) Rating	Disc. (Dry) Diff.	Disc. (GAWS) Rating	Disc. (GAWS) Diff.
GZ05	19	3.42	3.37	0.05	3.79	-0.37	3.58	-0.16
GZ06	10	2.00	2.00	0.00	2.00	0.00	2.30	-0.30
GZ-WM	14	2.93	2.79	0.14	3.21	-0.29	3.14	-0.21
GZSA1	42	2.14	2.19	-0.05	2.10	0.05	2.55	-0.40
GZSA2	23	1.96	2.00	-0.04	1.78	0.17	2.26	-0.30
GZSA3	24	2.33	2.38	-0.04	2.25	0.08	2.96	-0.62
MH05A	6	3.83	3.67	0.17	3.67	0.17	3.67	0.17
NF08	13	2.62	2.69	-0.08	2.62	0.00	3.15	-0.54
NF09	17	2.76	2.76	0.00	2.94	-0.18	3.18	-0.41
NF10	17	2.71	2.71	0.00	2.71	0.00	3.12	-0.41
NF11	13	2.69	2.77	-0.08	2.69	0.00	2.69	0.00
NF12	20	2.85	2.90	-0.05	2.50	0.35	2.90	-0.05
NF13	12	2.83	2.83	0.00	2.42	0.42	2.92	-0.08
PI06	17	3.94	3.94	0.00	4.00	-0.06	3.88	0.06
PI07	17	1.94	2.05	-0.12	1.88	0.06	2.06	-0.12
ST03	12	2.83	2.83	0.00	2.17	0.67	2.75	0.08
ST04	12	2.33	2.25	0.08	2.08	0.25	2.00	0.33
WN06	5	2.20	2.20	0.00	2.00	0.20	2.20	0.00
TR01	19	1.47	1.52	-0.05	1.53	-0.05	1.53	-0.05
TR02	17	1.94	1.94	0.00	2.47	-0.53	2.12	-0.18
UBC01	12	3.00	3.00	0.00	3.00	0.00	3.25	-0.25
UBC02	15	2.33	2.33	0.00	2.27	0.07	2.27	0.07
UBC03	18	1.72	1.72	0.00	1.67	0.06	1.78	-0.06
UBC04	18	2.56	2.56	0.00	2.50	0.06	2.50	0.06
WT01	16	1.62	1.56	0.06	1.62	0.00	1.62	0.00
WT02	15	1.53	1.47	0.07	1.47	0.07	1.47	0.07
WT03	20	2.15	2.10	0.05	1.95	0.20	2.00	0.15
WT04	19	1.95	1.95	0.00	1.84	0.11	2.05	-0.10
LBC01	18	2.89	2.89	0.00	3.22	-0.33	2.89	0.00
LBC02	17	1.35	1.41	-0.06	1.47	-0.12	1.47	-0.12
LBC03	20	2.40	2.35	0.05	2.70	-0.30	2.40	0.00
TB02	21	2.05	2.00	0.05	2.10	-0.05	2.33	-0.29
TB03	22	2.68	2.68	0.00	2.68	0.00	3.23	-0.54
TB04	19	1.89	1.84	0.05	1.79	0.10	1.95	-0.06
TB05	15	2.00	2.07	-0.07	2.00	0.00	2.13	-0.13
TB06	14	2.21	2.29	-0.07	2.21	0.00	2.36	-0.14
TB07	21	2.67	2.57	0.10	2.76	-0.10	2.81	-0.14
TB07A	16	2.06	2.06	0.00	2.19	-0.12	2.19	-0.12
TB08	17	2.41	2.41	0.00	2.47	-0.06	2.76	-0.35
TB09	14	2.93	2.93	0.00	2.93	0.00	3.86	-0.93
TB10	6	2.17	2.17	0.00	2.17	0.00	2.50	-0.33
TB11	15	3.07	3.07	0.00	2.87	0.20	3.07	0.00

The condition ratings in Table 5.3-4 are consistent with field observations and known grazing histories for the stations. Stations in 1210 and 1220 VBTs are ranked and brief descriptions of known management are given in Table 5.3-5. Reference stations that were subjectively selected to represent the natural or achievable state generally ranked low (i.e. in good condition). A notable exception (UBC02) is influenced by headcutting originating in UBC01, located immediately downstream.

As previously discussed, a station should include a distribution of various states. The distribution of states for three stations is illustrated in Figure 5.3-3. WT01 is in relatively good condition, GZSA3 is in fair condition, while MH05A is in poor condition. The distribution of states for a station may indicate the trend in condition. For a station with a low rating (good-condition), a few transects with scores of 3 or 4 may indicate impending deterioration under existing management.

Transects were clustered for stations with flowing streams in other valley-bottom types. Separate cluster and discriminant analyses were conducted for: 1) 2210 and 2220 VBTs; 2) 3310 and 3320 VBTs; 4) 1110 VBT; 5) 1120 VBT; 6) 1130 VBT; and 7) 2250 and 2260 VBTs. Ratings generated from both the clustering and discriminant functions were made for each station of these valley-bottom types (Tables 5.3-6 to 5.3-11). Good correspondence was found between the cluster and discriminant ratings for each station.

Condition ratings for glacial lands (1110, 1120, and 1130 VBTs) were calculated using only 9 of the 11 attributes used for other valley-bottom types. Impacts to these valley-bottom types result in over-broadened channels and braided streams, with little change in channel depth. Consequently, the ratios of channel cross-sectional area to stream cross-sectional area and channel depth were not considered.

Table 5.3-5. Ranking and synopses of management for stations located in fluvial lands in the sedimentary geologic district (1210 and 1220 VBTs).

Station	Rating	Management
LBC02*	1.35	BLM; LFSA; rested since 1972; stream structures present
TR01*	1.47	USFS; infrequently used horse pasture since 1900
WT02*	1.53	BLM; sheep allotment; some cattle trailing
WT01*	1.62	BLM; exp. pasture for high intensity/low-duration grazing
UBC03*	1.72	BLM; LFSA; rested since 1978
TB04	1.89	BLM; LFSA
TR02*	1.94	USFS; same as TR01
PI07	1.94	BLM; grazed in 1988; 1210 VBT
WT04*	1.95	BLM; same as WT01
GZSA2*	1.96	USFS; LFSA; rested since 1982
GZ06	2.00	USFS; rested since 1986; 1210 VBT
TB05	2.00	BLM; LFSA; rested since 1981
TB02	2.05	BLM; grazing management unknown
TB07A*	2.06	BLM; grazing management unknown
GZSA1	2.14	USFS; rested since 1986
WT03*	2.15	BLM; same as WT02
TB10	2.17	Private; seasonal grazing; 1210 VBT
WN06	2.20	USFS; grazing management unknown
TB06	2.21	BLM; LFSA
GZSA3	2.33	USFS; rested since 1986
ST04	2.33	USFS; management unknown; 1210 VBT;
UBC02*	2.33	BLM; LFSA; exclosed since 1982
LBC04	2.40	BLM; LFSA; seasonal grazing
TB08	2.41	BLM; grazing management unknown
UBC04	2.56	BLM; LFSA
NF08	2.61	USFS; rested since 1987
TB07	2.67	BLM; LFSA - rest/rotation since 1982
TB03	2.68	BLM; grazing management unknown
NF11	2.69	USFS; rested since 1987
NF09	2.76	USFS; rested since 1987
NF10	2.71	USFS; rested since 1987
NF13	2.83	USFS; rested since 1987; 1210 VBT
ST03	2.83	USFS; grazing management unknown
NF12	2.85	USFS; rested since 1987
LBC01	2.89	BLM; LFSA; seasonal grazing
TB09	2.92	Private; seasonal grazing
GZ-WM	2.96	USFS; rested since 1986
UBC01	3.00	BLM; LFSA; seasonal grazing
TB11	3.07	Private; seasonal grazing; incised channel
GZ05	3.42	USFS; channel incised > 6 feet in 1985; rested since 1986
MH05A	3.83	USFS; impacted by road; rested since 1986
PI06	3.94	Private; incised channel; grazed in 1988

* denotes preliminary reference stations

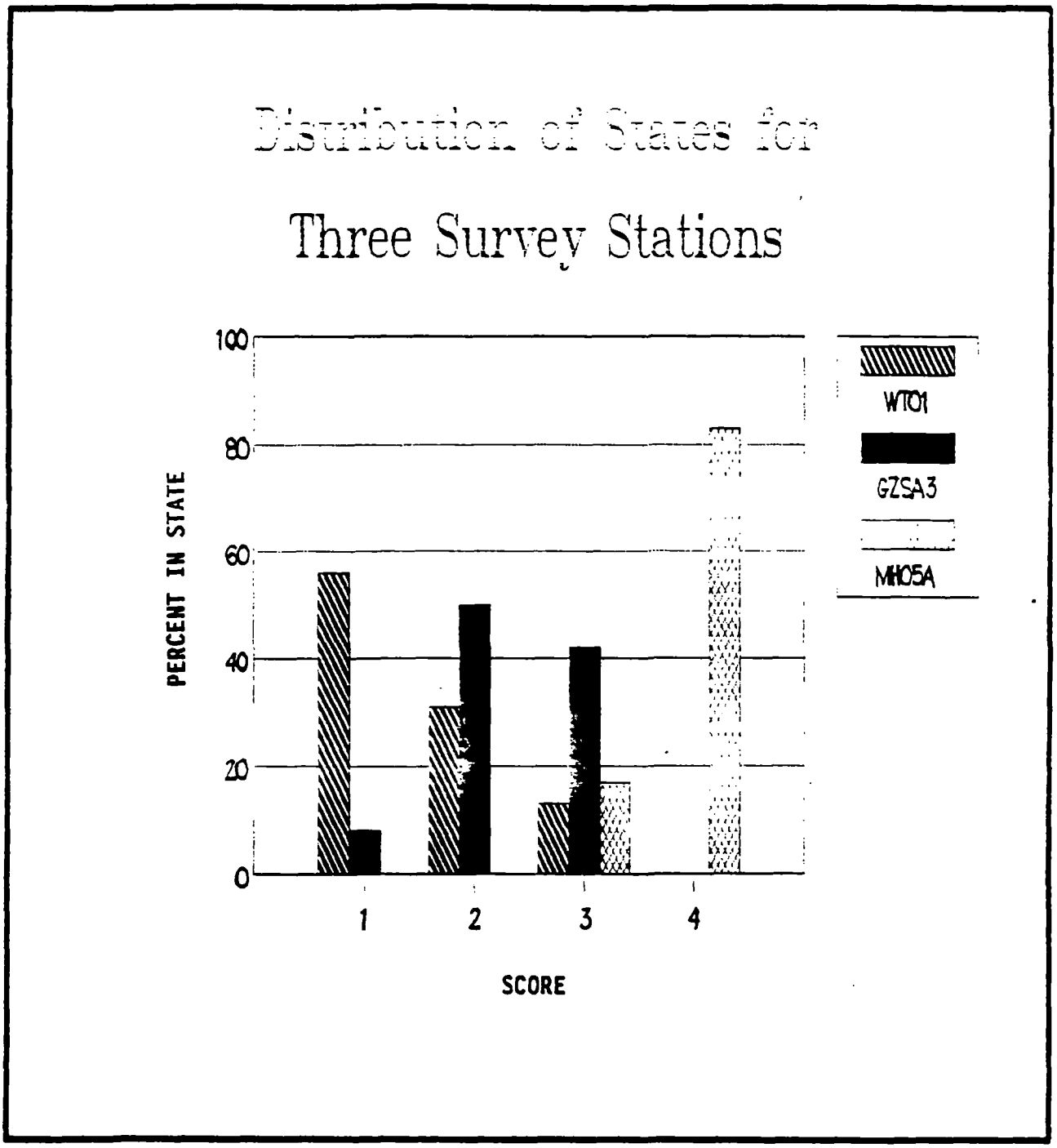


Figure 5.3-3. Distribution of states for three survey stations in relatively good (WT01), fair (GZSA3) and poor (MH05A) condition.

Table 5.3-6. Condition ratings for stations in fluvial (V-shaped) lands in the volcanic geologic district (2210 and 2220 VBTs) calculated from clustering, discriminant functions, dry station attributes and GAWS attributes, and differences from the cluster rating.

Site	N	Clus. Rating	Disc. (11) Rating	Disc. (11) Diff.	Disc. (Dry) Rating	Disc. (Dry) Diff.	Disc. (GAWS) Rating	Disc. (GAWS) Diff.
PI05	21	2.43	2.38	0.05	2.38	0.05	2.57	-0.14
MG01	22	2.09	2.04	0.05	2.00	0.09	2.09	0.00
MG02	16	1.62	1.62	0.00	1.50	0.12	1.69	-0.06
MG03	10	1.70	1.70	0.00	1.90	-0.20	1.70	0.00
DR01	7	2.43	2.43	0.00	2.43	0.00	2.57	-0.14
DR02	20	1.70	1.70	0.00	1.90	-0.20	1.60	0.10
DR03	12	1.00	1.00	0.00	1.17	-0.17	1.00	0.00
DR04	11	2.45	2.45	0.00	3.09	-0.64	2.27	0.18

Table 5.3-7. Condition ratings for stations in alluvial lands (3310 and 3320 VBTs) calculated from clustering, discriminant functions, dry station attributes and GAWS attributes, and differences from the cluster rating.

Site	N	Clus. Rating	Disc. (11) Rating	Disc. (11) Diff.	Disc. (Dry) Rating	Disc. (Dry) Diff.	Disc. (GAWS) Rating	Disc. (GAWS) Diff.
DO01	23	3.09	3.09	0.00	3.13	-0.04	3.04	0.04
GZ01	25	2.56	2.56	0.00	2.40	0.16	2.60	-0.04
GZ02	21	2.67	2.67	0.00	2.71	-0.05	3.00	-0.33
GZ03	24	2.25	2.25	0.00	2.29	-0.04	2.62	-0.38
GZ04	23	2.09	2.09	0.00	2.09	0.00	2.74	-0.65
NF03A	25	2.68	2.68	0.00	2.68	0.00	2.84	-0.16
NF05	24	2.54	2.58	-0.04	2.62	-0.08	2.75	-0.21
NF06	25	2.20	2.24	-0.04	2.20	0.00	2.52	-0.32
NF06A	24	2.96	2.88	0.08	3.42	-0.46	3.25	-0.29
NF07	13	3.85	3.77	0.08	3.92	-0.08	3.38	0.46
PI02	19	2.95	2.95	0.00	3.21	-0.26	3.11	-0.16
PI03	25	2.84	2.88	-0.04	2.84	0.00	2.92	-0.08

Table 5.3-8. Condition ratings for stations in glacial basins (1110 VBT) calculated from clustering, discriminant functions, dry station attributes and GAWS attributes.

Site	N	Clus. Rating	Disc. (11) Rating	Disc. (11) Diff.	Disc. (Dry) Rating	Disc. (Dry) Diff.	Disc. (GAWS) Rating	Disc. (GAWS) Diff.
PR07	10	2.70	2.70	0.00	2.70	0.00	2.70	0.00

Table 5.3-9. Condition ratings for stations in glacial trains (1120 VBT) calculated from clustering, discriminant functions, dry station attributes and GAWS attributes, and differences from the cluster rating.

Site	N	Clus. Rating	Disc. (11) Rating	Disc. (11) Diff.	Disc. (Dry) Rating	Disc. (Dry) Diff.	Disc. (GAWS) Rating	Disc. (GAWS) Diff.
FM06	12	2.83	2.83	0.00	2.83	0.00	2.83	0.00
FM07	11	2.64	2.64	0.00	2.64	0.00	2.64	0.00
FM08	8	2.75	2.88	-0.12	2.50	0.25	2.88	-0.12
FM09	12	2.67	2.67	0.00	2.67	0.00	2.67	0.00
PR05	20	2.85	2.85	0.00	2.80	0.05	2.85	0.00
PR06	11	2.73	2.73	0.00	2.82	-0.09	2.73	0.00

Table 5.3-10. Condition ratings for stations in glacial outwasn (1130 VBT) calculated from clustering, discriminant functions, dry station attributes and GAWS attributes, and differences from the cluster rating.

Site	N	Clus. Rating	Disc. (11) Rating	Disc. (11) Diff.	Disc. (Dry) Rating	Disc. (Dry) Diff.	Disc. (GAWS) Rating	Disc. (GAWS) Diff.
FM05	23	2.70	2.70	0.00	2.70	0.00	2.70	0.00

Table 5.3-11. Condition ratings for stations in fluvial (notch-shaped) canyons in the volcanic geologic district (2250 and 2260 VBTs) calculated from clustering, discriminant functions, dry station attributes and GAWS attributes, and differences from the cluster rating.

Site	N	Clus. Rating	Disc. (11) Rating	Disc. (11) Diff.	Disc. (Dry) Rating	Disc. (Dry) Diff.	Disc. (GAWS) Rating	Disc. (GAWS) Diff.
NF01	21	2.81	2.81	0.00	2.81	0.00	2.81	0.00
NF04	6	2.67	2.67	0.00	2.67	0.00	2.67	0.00
PI01	20	2.90	2.90	0.00	2.90	0.00	2.90	0.00

Ratings from cluster and discriminant functions were also created for all stations in non-glacial (i.e. combined 1210, 1220, 2210, 2220, 3210, 3220 VBTs) and glacial lands (i.e. combined 1110, 1120 and 1130 VBTs). Results are presented in Tables 5.3-12 and 5.3-13. The correspondence between these ratings and those developed for specific valley-bottom types is relatively good, although differences are greater than 0.5 for some stations in volcanic (2000) and tuffaceous (3000) geologic districts. The correspondence may have been due to the over-representation of sites in the sedimentary (1000) geologic district. Differences indicate that clustering of sites across geologic districts may decrease the accuracy of assessments. This supports the need for full classification of streams prior to condition assessment.

Clustering and discriminant functions were also used to determine scores where bank-forming landforms were not floodplain and levee (i.e. alluvial, moraine and residual). These discriminant functions were used for some stations in V-shaped erosional (1210 and 2210) valley-bottom types, where alluvial and residual bank-forming landforms are common. However, these condition ratings may not be as good as those developed for floodplain and levee bank-forming landforms because the other landforms are inherently more unstable and less sensitive to nps impacts. The coefficient of variation for channel attributes with streambanks that are moraines, alluvial fans or residual is generally lower than for streambanks that are floodplain and levee.

Condition ratings were calculated for each station based upon clustering or discriminant functions (Table 5.3-14). The origin of the rating and the percent distribution of transects with a given score are tabulated. Coefficients for all discriminant functions are listed in APPENDIX J.

Table 5.3-12. Ratings calculated from clustering of all stations of nonglacial lands with flowing streams. Ratings from discriminant functions for 11 attributes, dry-stream attributes and GAWS attributes are also shown. Differences between these ratings and those calculated for specific valley-bottom types are shown.

Site	N	VBT Clus. Rating	Nonglacial Clustering Rating	Diff	Nonglacial Discriminant Rating	Diff	Nonglacial Disc. (dry) Rating	Diff	Nonglacial Disc. (GAWS) Rating	Diff
LBC01	18	2.89	2.89	0.00	2.89	0.00	3.11	-0.22	2.89	0.00
LBC02	17	1.35	1.35	0.00	1.41	-0.06	1.35	0.00	1.41	-0.06
LBC03	20	2.40	2.40	0.00	2.30	0.10	2.65	-0.25	2.30	0.10
UBC01	12	3.00	2.83	0.17	2.83	0.17	2.67	0.33	3.33	-0.33
UBC02	15	2.33	2.33	0.00	2.33	0.00	2.33	0.00	2.40	-0.07
UBC03	18	1.72	1.72	0.00	1.72	0.00	1.56	0.17	1.72	0.00
UBC04	18	2.56	2.56	0.00	2.56	0.00	2.56	0.00	2.33	0.22
CM01	24	4.00	4.00	0.00	4.00	0.00	4.00	0.00	3.75	0.25
CM02a	9	2.89	2.00	0.89	2.00	0.89	2.00	0.89	2.11	0.78
CM02b	12	3.00	3.00	0.00	3.00	0.00	3.00	0.00	3.33	-0.33
CM03	14	2.43	1.93	0.50	2.00	0.43	1.92	0.50	2.00	0.43
D001	23	3.09	3.09	0.00	3.09	0.00	3.13	-0.04	3.74	-0.65
DR01	7	2.43	2.14	0.29	2.14	0.29	2.14	0.29	2.00	0.43
DR02	20	1.70	1.85	-0.15	2.05	-0.35	1.70	0.00	1.90	-0.20
DR03	12	1.00	1.33	-0.33	1.50	-0.50	1.25	-0.25	1.42	-0.42
DR04	11	2.45	2.54	-0.09	2.54	-0.09	2.64	-0.18	2.27	0.18
GZ01	25	2.56	2.56	0.00	2.52	0.04	2.48	0.08	2.60	-0.04
GZ02	21	2.67	2.76	-0.10	2.62	0.05	2.71	-0.05	3.43	-0.76
GZ03	24	2.25	2.04	0.21	2.17	0.08	1.96	0.29	2.38	-0.12
GZ04	23	2.09	2.26	-0.17	2.22	-0.13	2.26	-0.17	2.83	-0.74
GZ05	19	3.42	3.42	0.00	3.53	-0.11	3.68	-0.26	3.16	0.26
GZ-WM	14	2.93	2.86	0.07	2.79	0.14	3.14	-0.21	2.93	0.00
GZSA1	42	2.14	2.19	-0.05	2.19	-0.05	2.17	-0.02	2.50	-0.36
GZSA2	23	1.96	1.87	0.09	1.96	0.00	1.78	0.17	2.35	-0.39
GZSA3	24	2.33	2.33	0.00	2.38	-0.04	2.29	0.04	2.92	-0.58
GZ06	10	2.00	2.00	0.00	2.00	0.00	2.00	0.00	2.40	-0.40
MG01	22	2.09	2.36	-0.27	2.36	-0.27	2.27	-0.18	2.05	0.05
MG02	16	1.62	1.81	-0.19	1.81	-0.19	1.81	-0.19	1.94	-0.31
MG03	10	1.70	1.80	-0.10	1.80	-0.10	1.80	-0.10	1.80	-0.10
MH05A	6	3.83	3.50	0.33	3.50	0.33	3.50	0.33	3.67	0.17
NF01	21	2.81	2.71	0.10	2.81	0.00	2.52	0.29	2.62	0.19
NF04	6	2.67	2.67	0.00	2.67	0.00	3.00	-0.33	2.83	-0.17
NF03A	25	2.68	2.84	-0.16	2.84	-0.16	2.52	0.16	3.68	-1.00
NF05	24	2.54	2.83	-0.29	2.75	-0.21	2.75	-0.21	2.62	-0.08
NF06	25	2.20	2.08	0.12	2.00	0.20	2.12	0.08	2.36	-0.16
NF06A	24	2.96	2.92	0.04	2.92	0.04	2.92	0.04	3.08	-0.12
NF07	13	3.85	3.92	-0.08	3.92	-0.08	3.92	-0.08	3.46	0.38
NF08	13	2.62	2.62	0.00	2.62	0.00	2.62	0.00	2.69	-0.08
NF09	17	2.76	2.76	0.00	2.76	0.00	2.82	-0.06	3.06	-0.29
NF10	17	2.71	2.77	-0.06	2.71	0.00	2.71	0.00	2.88	-0.18
NF11	13	2.69	2.77	-0.08	2.85	-0.15	2.62	0.08	2.31	0.38
NF12	20	2.85	2.70	0.15	2.75	0.10	2.40	0.45	2.75	0.10
NF13	12	2.83	2.67	0.17	2.75	0.08	2.33	0.50	2.92	-0.08

Table 5.3-12. (Continued).

Site	N	VBT Clus. Rating	Nonglacial Clustering Rating	Diff	Nonglacial Discriminant Rating	Diff	Nonglacial Disc. (dry) Rating	Diff	Nonglacial Disc. (GAWS) Rating	Diff
PI01	20	2.90	2.80	0.10	2.70	0.20	3.00	-0.10	3.60	-0.70
PI02	19	2.95	3.05	-0.11	3.05	-0.11	3.21	-0.26	3.74	-0.79
PI03	25	2.84	2.92	-0.08	2.92	-0.08	2.84	0.00	3.44	-0.60
PI04	23	2.13	2.17	-0.04	2.17	-0.04	2.17	-0.04	2.30	-0.17
PI05	21	2.43	2.24	0.19	2.24	0.19	2.19	0.24	2.38	0.05
PI06	17	3.94	4.00	-0.06	4.00	-0.06	4.00	-0.06	3.88	0.06
PI07	17	1.94	1.94	0.00	1.94	0.00	1.88	0.06	2.06	-0.12
ST03	12	2.83	2.67	0.17	2.67	0.17	2.17	0.67	2.75	0.08
ST04	12	2.33	2.17	0.17	2.17	0.17	2.17	0.17	2.00	0.33
TB02	21	2.05	2.00	0.05	2.05	0.00	2.19	-0.14	2.43	-0.38
TB03	22	2.68	2.64	0.05	2.64	0.05	2.73	-0.05	3.36	-0.68
TB04	19	1.89	2.05	-0.16	2.11	-0.22	2.05	-0.16	1.89	-0.01
TB05	15	2.00	2.27	-0.27	2.14	-0.13	2.20	-0.20	2.07	-0.07
TB06	14	2.21	2.14	0.07	2.14	0.07	2.21	0.00	2.21	0.00
TB07	21	2.67	2.62	0.05	2.67	0.00	2.90	-0.24	2.95	-0.29
TB07A	16	2.06	2.06	0.00	2.06	0.00	2.19	-0.12	2.19	-0.12
TB08	17	2.41	2.41	0.00	2.41	0.00	2.35	0.06	2.94	-0.53
TB09	14	2.93	2.93	0.00	2.93	0.00	2.93	0.00	3.86	-0.93
TB10	6	2.17	2.17	0.00	2.17	0.00	2.17	0.00	2.83	-0.67
TB11	15	3.07	2.93	0.13	2.87	0.20	2.80	0.27	3.20	-0.13
TR01	19	1.47	1.53	-0.05	1.53	-0.05	1.53	-0.05	1.63	-0.16
TR02	17	1.94	1.94	0.00	2.00	-0.06	2.47	-0.53	2.29	-0.35
WN06	5	2.20	2.20	0.00	2.20	0.00	2.00	0.20	2.20	0.00
WT01	16	1.62	1.62	0.00	1.56	0.06	1.56	0.06	1.50	0.12
WT02	15	1.53	1.53	0.00	1.53	0.00	1.40	0.13	1.47	0.07
WT03	20	2.15	2.15	0.00	2.20	-0.05	1.95	0.20	2.05	0.10
WT04	19	1.95	1.89	0.05	2.05	-0.10	1.84	0.11	1.89	0.05

Table 5.3-13. Ratings calculated from clustering of all stations in glacial lands. Ratings from discriminant functions for 11 attributes, dry-stream attributes and GAWS attributes are also shown. Differences between these ratings and those calculated by similar landtype association (LA) or valley-bottom type (VBT) are shown.

Site	N	LA/VBT Clus. Rating	Glacial Clustering Rating	Glacial Clustering Diff	Glacial Discriminant Rating	Glacial Discriminant Diff	Glacial Disc. (dry) Rating	Glacial Disc. (dry) Diff	Glacial Disc. (GAWS) Rating	Glacial Disc. (GAWS) Diff
FM05	23	2.70	2.70	0.00	2.70	0.00	2.70	0.00	2.70	0.00
FM06	12	2.83	2.83	0.00	2.83	0.00	2.83	0.00	2.83	0.00
FM07	11	2.64	2.64	0.00	2.64	0.00	2.64	0.00	2.64	0.00
FM08	8	2.75	2.75	0.00	2.62	0.12	2.50	0.25	2.62	0.12
FM09	12	2.67	2.67	0.00	2.67	0.00	2.67	0.00	2.67	0.00
PR05	20	2.85	2.80	0.05	2.80	0.05	2.80	0.05	2.80	0.05
PR06	11	2.73	2.73	0.00	2.73	0.00	2.82	-0.09	2.73	0.00
PR07	10	2.70	2.70	0.00	2.70	0.00	2.60	0.10	2.70	0.00

Table 5.3-14. Ratings, derivation of each rating and the percent of cross-sections with a given score for all survey stations.

Site	Class	N	Rating	Score 1	2	3	4	Rating Derivation npt*npt
CM01	3220	24	4.00	0	0	0	100	Class 3200; LF: 2 and 3; Cluster
CM02a	3220	9	2.89	0	11	89	0	Class 3200; LF: 2 and 3; Cluster
CM02b	3220	12	3.00	0	0	100	0	Class 3200; LF: 2 and 3; Cluster
CM03	3220	14	2.43	0	57	43	0	Class 3200; LF: 2 and 3; Cluster
CM04a	3220	12	1.92	8	92	0	0	Non-glacial; LF: 4, 5, 6; Dry disc. funct.
CM04b	3220	13	4.00	0	0	0	100	Non-glacial; LF: 4, 5, 6; Dry disc. funct.
DO01	3320	23	3.09	0	0	91	9	Class 3300; LF: 2 and 3; Cluster
DR01	2210	7	2.43	29	29	14	29	Class 2200; LF: 2 and 3; Cluster
DR02	2210	20	1.70	45	45	5	5	Class 2200; LF: 2 and 3; Cluster
DR03	2210	12	1.00	100	0	0	0	Class 2200; LF: 2 and 3; Cluster
DR04	2210	11	2.45	9	36	55	0	Class 2200; LF: 2 and 3; Cluster
FM02	3320	23	2.09	0	91	9	0	Class 3300; LF: 2 and 3; Dry disc. funct.
FM05	1130	23	2.70	0	30	70	0	Class 1130; LF: 2 and 3; Cluster
FM06	1120	12	2.83	0	17	83	0	Class 1120; LF: 2 and 3; Cluster
FM07	1120	11	2.64	0	36	64	0	Class 1120; LF: 2 and 3; Cluster
FM08	1120	8	2.75	0	25	75	0	Class 1120; LF: 2 and 3; Cluster
FM09	1120	12	2.67	0	33	67	0	Class 1120; LF: 2 and 3; Cluster
GZ-WM	1220	14	2.93	0	29	50	21	Class 1200; LF: 2 and 3; Cluster
GZ01	3320	25	2.56	0	56	32	12	Class 3300; LF: 2 and 3; Cluster
GZ02	3310	21	2.67	0	33	67	0	Class 3300; LF: 2 and 3; Cluster
GZ03	3310	24	2.25	0	75	25	0	Class 3300; LF: 2 and 3; Cluster
GZ04	3310	23	2.09	0	91	9	0	Class 3300; LF: 2 and 3; Cluster
GZ05	1220	19	3.42	0	11	37	53	Class 1200; LF: 2 and 3; Cluster
GZ06	1210	10	2.00	0	100	0	0	Class 1200; LF: 2 and 3; Cluster
GZSA1	1220	42	2.14	10	67	24	0	Class 1200; LF: 2 and 3; Cluster
GZSA2	1220	23	1.96	22	61	17	0	Class 1200; LF: 2 and 3; Cluster
GZSA3	1210	24	2.33	8	50	42	0	Class 1200; LF: 2 and 3; Cluster
JM01	3310	21	2.43	0	57	43	0	Class 3300; LF: 2 and 3; Dry disc. funct.
JM02	3310	24	2.00	0	100	0	0	Class 3300; LF: 2 and 3; Dry disc. funct.
JM04	1210	25	2.12	4	84	8	4	Non-glacial; LF: 4, 5, 6; Dry disc. funct.
LBC01	1220	18	2.89	6	0	94	0	Class 1200; LF: 2 and 3; Cluster
LBC02	1220	17	1.35	71	24	6	0	Class 1200; LF: 2 and 3; Cluster
LBC03	1220	20	2.40	25	10	65	0	Class 1200; LF: 2 and 3; Cluster
MG01	2220	22	2.09	45	0	55	0	Class 2200; LF: 2 and 3; Cluster
MG02	2220	16	1.62	50	38	13	0	Class 2200; LF: 2 and 3; Cluster
MG03	2210	10	1.70	30	70	0	0	Class 2200; LF: 2 and 3; Cluster

(*) LF = landform; 2 = levee; 3 = floodplain; 4 = alluvial fan
5 = colluvial; 6 = residual

Table 5.3-14. (Continued)

Site	Class	N	Rating	Score 1	2	3	4	Rating Derivation
MH01	3320	25	2.12	0	88	12	0	Class 3300; LF: 2 and 3; Dry disc. funct.
MH02	3320	25	2.00	0	100	0	0	Class 3300; LF: 2 and 3; Dry disc. funct.
MH03	3310	24	2.00	0	100	0	0	Class 3300; LF: 2 and 3; Dry disc. funct.
MH05	1220	15	2.60	0	40	60	0	Class 1200; LF: 2 and 3; Dry disc. funct.
MH05A	1220	6	3.83	0	0	17	83	Class 1200; LF: 2 and 3; Cluster
MH06	1220	24	3.38	0	17	29	54	Class 1200; LF: 2 and 3; Dry disc. funct.
NF01	2250	21	2.81	0	19	81	0	Class 2250; LF: 2 and 3; Cluster
NF03A	3320	25	2.68	0	32	68	0	Class 3300; LF: 2 and 3; Cluster
NF04	2250	6	2.67	0	33	67	0	Class 2250; LF: 2 and 3; Cluster
NF05	3320	24	2.54	0	46	54	0	Class 3300; LF: 2 and 3; Cluster
NF06	3320	25	2.20	0	80	20	0	Class 3300; LF: 2 and 3; Cluster
NF06A	3320	24	2.96	0	17	71	13	Class 3300; LF: 2 and 3; Cluster
NF07	3310	13	3.85	0	0	15	85	Class 3300; LF: 2 and 3; Cluster
NF08	1220	13	2.62	8	23	69	0	Class 1200; LF: 2 and 3; Cluster
NF09	1220	17	2.76	12	0	88	0	Class 1200; LF: 2 and 3; Cluster
NF10	1220	17	2.71	12	6	82	0	Class 1200; LF: 2 and 3; Cluster
NF11	1220	13	2.69	8	23	62	8	Class 1200; LF: 2 and 3; Cluster
NF12	1220	20	2.85	5	20	60	15	Class 1200; LF: 2 and 3; Cluster
NF13	1210	12	2.83	8	25	42	25	Class 1200; LF: 2 and 3; Cluster
PI01	2250	20	2.90	0	10	90	0	Class 2250; LF: 2 and 3; Cluster
PI02	3320	19	2.95	0	5	95	0	Class 3300; LF: 2 and 3; Cluster
PI03	3310	25	2.84	0	16	84	0	Class 3300; LF: 2 and 3; Cluster
PI04	2310	23	2.13	0	87	13	0	Class 2300; LF: 2 and 3; Cluster
PI05	2220	21	2.43	0	62	33	5	Class 2200; LF: 2 and 3; Cluster
PI06	1220	17	3.94	0	0	6	94	Class 1200; LF: 2 and 3; Cluster
PI07	1210	17	1.94	18	71	12	0	Class 1200; LF: 2 and 3; Cluster
PR04	1130	16	2.94	0	6	94	0	Class 1130; LF: 2 and 3; Dry disc. funct.
PR05	1120	20	2.85	0	15	85	0	Class 1120; LF: 2 and 3; Cluster
PR06	1120	11	2.73	0	27	73	0	Class 1120; LF: 2 and 3; Cluster
PR07	1110	10	2.70	0	30	70	0	Class 1110; LF: 2 and 3; Cluster
SH01	3310	7	2.14	0	86	14	0	Class 3300; LF: 2 and 3; Dry disc. funct.
SH02	1220	5	2.00	0	100	0	0	Class 1200; LF: 2 and 3; Dry disc. funct.
SH03	1210	24	2.04	0	96	4	0	Non-glacial; LF: 4, 5, 6; Dry disc. funct.
SH04	1210	5	2.00	0	100	0	0	Class 1200; LF: 2 and 3; Dry disc. funct.
ST01	3310	16	2.75	0	31	63	6	Class 3300; LF: 2 and 3; Dry disc. funct.
ST02	1210	25	2.20	0	80	20	0	Non-glacial; LF: 4, 5, 6; Dry disc. funct.
ST03	1220	12	2.83	0	42	33	25	Class 1200; LF: 2 and 3; Cluster
ST04	1220	12	2.33	8	67	8	17	Class 1200; LF: 2 and 3; Cluster

Table 5.3-14. (Continued)

Site	Class	N	Rating	Score 1	2	3	4	Rating Derivation
TB02	1220	21	2.05	24	48	29	0	Class 1200; LF: 2 and 3; Cluster
TB03	1220	22	2.68	14	5	82	0	Class 1200; LF: 2 and 3; Cluster
TB04	1220	19	1.89	32	42	21	0	Class 1200; LF: 2 and 3; Cluster
TB05	1220	15	2.00	27	47	27	0	Class 1200; LF: 2 and 3; Cluster
TB06	1220	14	2.21	14	50	36	0	Class 1200; LF: 2 and 3; Cluster
TB07	1220	21	2.67	5	24	71	0	Class 1200; LF: 2 and 3; Cluster
TB07A	1220	16	2.06	19	56	25	0	Class 1200; LF: 2 and 3; Cluster
TB08	1220	17	2.41	18	24	59	0	Class 1200; LF: 2 and 3; Cluster
TB09	1220	14	2.93	0	7	93	0	Class 1200; LF: 2 and 3; Cluster
TB10	1210	6	2.17	33	17	50	0	Class 1200; LF: 2 and 3; Cluster
TB11	1220	15	3.07	0	13	67	20	Class 1200; LF: 2 and 3; Cluster
TR01	1220	19	1.47	68	16	16	0	Class 1200; LF: 2 and 3; Cluster
TR02	1220	17	1.94	47	12	41	0	Class 1200; LF: 2 and 3; Cluster
UBC01	1220	12	3.00	0	0	100	0	Class 1200; LF: 2 and 3; Cluster
UBC02	1220	15	2.33	0	67	33	0	Class 1200; LF: 2 and 3; Cluster
UBC03	1220	18	1.72	33	61	6	0	Class 1200; LF: 2 and 3; Cluster
UBC04	1220	18	2.56	6	33	61	0	Class 1200; LF: 2 and 3; Cluster
WN01	3130	20	2.95	0	5	95	0	Class 3130; LF: 2 and 3; Dry disc. funct.
WN02	2220	17	2.94	0	24	59	18	Class 2200; LF: 2 and 3; Dry disc. funct.
WN03	1220	10	2.00	20	60	20	0	Class 1200; LF: 2 and 3; Dry disc. funct.
WN04	1220	9	2.44	0	56	44	0	Class 1200; LF: 2 and 3; Dry disc. funct.
WN05	1220	21	3.05	0	5	86	10	Class 1200; LF: 2 and 3; Dry disc. funct.
WN06	1210	5	2.20	0	80	20	0	Class 1200; LF: 2 and 3; Cluster
WN07	1110	25	2.56	0	60	24	16	Glacial; LF: 4, 5, 6, 8; Dry disc. funct.
WNN1	1130	12	2.75	0	25	75	0	Glacial; LF: 2 and 3; Dry disc. funct.
WNN2	1120	14	2.64	0	36	64	0	Class 1120; LF: 2 and 3; Dry disc. funct.
WT01	1220	16	1.62	50	38	13	0	Class 1200; LF: 2 and 3; Cluster
WT02	1220	15	1.53	47	53	0	0	Class 1200; LF: 2 and 3; Cluster
WT03	1220	20	2.15	5	75	20	0	Class 1200; LF: 2 and 3; Cluster
WT04	1220	19	1.95	16	74	11	0	Class 1200; LF: 2 and 3; Cluster

With the development of discriminant functions, a researcher has a tool to assess the condition of other stations within the same class of RRH. The discriminant functions also provide a tool for monitoring a station over time. Changes in the rating of a station indicate degradation or improvement under a defined management practice. For the 1220 VBT, a trend moving toward a 3 rating would indicate that the station is headed for degradation and severe bank erosion under current management.

Discriminant functions can be calculated using fewer attributes from each transect. A subset of attributes can be selected according to their probability of allowing useful discriminations to be made. The accuracy of transect scores determined from discriminant functions using 1 to 11 attributes, relative to the score determined by clustering is illustrated in Figure 5.3-4. Attributes were added in the following order: 1) Area of channel/area of stream, 2) Stream width/depth, 3) Bank water depth, 4) Percent of banks eroded, 5) Depth of channel, 6) Bank undercut, 7) Bank stability, 8) Percent of banks with stream bars and/or percent eroded, 9) Channel width to stream width, 10) Channel width/depth and 11) Bank angle. The first 6 of these attributes could be used to obtain the correct score for 90.1 percent of all transects. These attributes were the most important for discriminating the scores for transects and condition ratings for stations. The attributes which were the most discriminating vary between the classes clustered and are in part functions of the correlation between attributes. Four survey stations with contrasting condition ratings are illustrated in Figure 5.3-5.

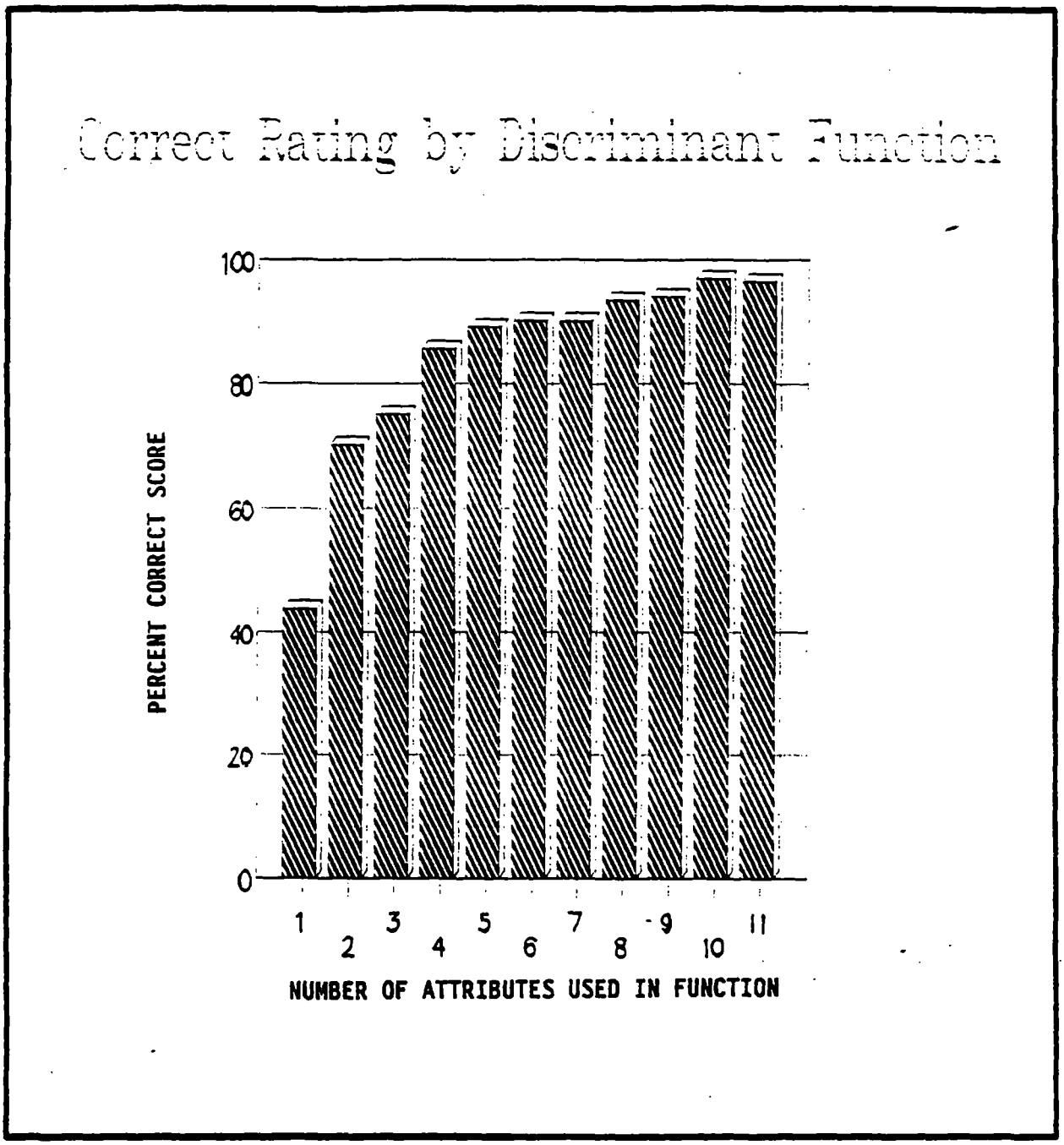


Figure 5.3-4. Percent of transects rated correctly by discriminant functions generated using 1 to 11 attributes.

A) TROI (Rating = 1.47)

B) WTOI (Rating = 1.62)

C) GZO3 (Rating = 2.25)

D) GZO5 (Rating = 3.42)

Figure 5.3-5. Survey stations.

5.3.2 Condition Rating for Dry Stations

Where streams were dry at the time of measurement, only 7 of the original 11 attributes could be measured (Table 5.3-15). Consequently, these stations could not be clustered with the other 42 stations or rated using the discriminant function generated from 11 attributes. In order to test the discriminating ability of the 7 attributes that could be measured for dry stations, they were used to determine condition ratings for the stations which contained water during the survey (Tables 5.3-4 through 5.3-13). These condition ratings were generally very similar to the condition ratings calculated using 11 attributes, indicating a relatively good discriminating ability.

The discriminant functions developed from the 7 attributes were then used to calculate condition ratings for dry stations, which are included on Table 5.3-14.

Table 5.3-15. Attributes that could be measured for stations that were dry; attributes that are measured for typical GAWS (Level II) inventories; and attributes used for cluster and discriminant analyses of stations in glacial lands.

No.	Attribute	Dry	GAWS	Glacial
1	% of banks eroded or with bars	*		*
2	% of banks eroded	*		*
3	Bank angle (deg)	*	*	*
4	Bank undercut (ft)	*	*	*
5	Bank water depth (ft)		*	*
6	Bank stability (rating)	*	*	*
7	Depth of channel (ft)	*		
8	Channel width/depth	*		*
9	Stream width/depth		*	*
10	Channel width/stream width			*
11	Area of channel/area of stream			

5.3.3 Condition Ratings using GAWS Data

An extensive amount of data has been collected for use in the General Aquatic Wildlife System (GAWS) (USFS 1985). This information has been used to assess the condition of a stream for fish but has had limited use in assessing the condition of a RRH relative to its potential. Assessment of a station using the GAWS is independent of the stations potential condition.

If attributes measured for GAWS investigations (Table 5.3-15) could be tied to the condition of a RRH relative to its potential, this extensive database might be used to estimate the condition rating for the GAWS stations. Of the 11 attributes used to cluster and develop discriminant functions, five are measured or can be determined using data from a typical GAWS dataset. These five attributes were used to generate discriminant functions from the scores determined by clustering. These discriminant functions were used to predict the score for each transect and to determine condition ratings for survey stations. The condition ratings calculated from GAWS data are listed in Tables 5.3-4 through 5.3-13. Ratings are very similar to those calculated using 11 attributes.

The results of this analysis indicated that GAWS data could be used to assess the condition of RRH with a reasonable degree of accuracy if the bank-forming landforms (see Table 4.6-1) for transects could be ascertained. The condition ratings are likely to be less accurate when the bank-forming landforms cannot be determined as the attributes vary between landforms under the same management. These analyses suggest that, with a few modifications, the GAWS database could be used to assess condition and trend of RRH.

This page is intentionally blank.

5.4 Assessment of Vegetative Attributes

Changes in the state of RRH, as documented by measurement of stream and channel attributes, were expected to correspond with changes in the bank-forming vegetation type. For the hypothetical progression of states illustrated in Figure 5.3-1, the deterioration of RRH corresponds with: 1) elimination of hydric, bank-forming vegetation; 2) encroachment of upland vegetation onto floodplains and levees; and 3) increase in the extent of eroded banks and streambars at the expense of vegetated communities on levees and floodplains. Given this hypothetical progression, the bank-forming vegetation types for transects should be related to the scores of transects determined from cluster and discriminant analyses (see Section 5.3.1. The distribution of scores for bank-forming vegetation types identified along transects of 110 survey stations are summarized in Table 5.4-1. Bank-forming vegetation types that were identified on fewer than 10 transects were not considered.

For herbaceous vegetation types, the more hydric (wetter) bank-forming vegetation types scored in the lower end of the range (better condition). A similar trend was evident for shrub vegetation types. These trends corroborate the progression of states identified from clustering and discriminant analyses of stream and channel attributes. A single forested bank-forming vegetation type was identified (POTR/MH). This vegetation type is dominated by aspen, a facultative upland species that is little affected by channel incision and lowered groundwater levels. The broad range of scores for POTR/MH indicate that it is tolerant of a broad range of states.

Table 5.4-1. Percent distribution of scores for vegetation types identified on transects of 110 survey stations; vegetation types within a physiognomic class are ordered from wet to dry.

VEGETATION TYPE	N	SCORE				AVERAGE
		1	2	3	4	
HERBACEOUS TYPES						
CANE RPT	73	44	42	14	0	1.72
POPR RPT	553	21	39	39	1	2.21
AGST RPT	60	10	40	50	0	2.40
HAY RPT-	137	0	47	50	3	2.55
WEED RPT-	28	14	14	64	7	2.64
SHRUB TYPES						
SALIX/MH RPT	629	13	46	37	4	2.33
SAEX/MH RPT	101	1	51	45	3	2.50
ALIN/MH RPT	93	0	25	74	1	2.76
MXSH/GM RPT-*	213	11	20	57	12	2.70
ARTR-UP UPT	137	4	13	41	42	3.22
ARTR-CHNA	172	3	19	76	24	3.66
UPLAND SHRUB UPT	12	0	0	42	58	3.58
FORESTED TYPES						
POTR/MH RPT	174	25	23	44	8	2.36

(*) includes ARTR/POPR RPT-.

In general the drier bank-forming vegetation types were more frequently associated with higher scores (worse condition) determined from cluster and discriminant analyses. We observed that changes in vegetation types occurred quickly on the level of and immediately adjacent to stream and more slowly with distance from and height above the stream. While indications of improving condition in response to rest from livestock were apparent in stream/channel attributes and in bank-forming vegetation types, trends were less apparent when the entire valley-bottom was considered. The distribution of vegetation types across the valley-bottom reflects a longer-term (normal) condition and responds slower to to changes in management.

5.5 Assessment of Fish Attributes

Five species of fish were identified in the NFH study area: 1) speckled dace (*Rhinichthys osculus*); 2) redsided shiner (*Richarsonius bateatus*); 3) Paiute sculpin (*Cottus beldingi*); 4) brook trout (*Salvelinus fontinalis*); and 5) Lahontan cutthroat trout (*Salmo clarki henshawi*). Trout were present in five of the ten tributaries of the NFH River that were sampled (North Fork, Pratt, Foreman, Gance and Pie Creeks). Streamflow was intermittent or ephemeral in Dorsey, Jim, Mahala, Sheep and Stump Creeks and no trout were recorded. Stream discharge was lower than normal during 1988, the third consecutive dry year in northern Nevada. Many stream reaches shown as perennial on USGS maps were dry in 1988. Along intermittent streams, it is likely that trout were present in some beaver ponds that held water throughout the dry season. The distribution of trout in 71 survey stations in the NFH study area is summarized by valley-bottom type in Table 5.5-1.

Trout were found in two glacial valley-bottom types (1120 and 1130). No trout were found in glacial basins (1110 VBT). Streams are very steep (17 to 32 percent slope) and usually intermittent where they cross terminal moraines at the downstream end of glacial basins, imposing barriers to fish migration. Trout were present in all stations in glacial trains (1120 VBT). Only cutthroat trout were found on Foreman Creek, while only brook trout were found on Pratt Creek, possibly due to stocking. Cutthroat trout were also found in the glacial outwash (1130) valley-bottom type of Foreman Creek, the only station in this VBT with perennial streamflow.

Table 5.5-1. Average trout biomass for survey stations in the NFH study area, sorted by valley-bottom type (VBT).

VBT	---N---		---Cutthroat--			-----Brook----			----Total----		
	P (1)	I (2)	N (3)	AVE	SD	N (4)	AVE	SD	N (5)	AVE	SD
1110	2	1	0	-	-	0	-	-	0	-	-
1120	6	0	4	0.48	0.28	2	0.78	0.18	6	0.58	0.28
1130	1	4	1	0.25	-	0	-	-	1	0.25	-
1210	3	7	1	0.17	-	0	-	-	1	0.17	-
1220	12	8	10	0.32	0.27	2	0.19	0.17	12	0.30	0.26
2210	0	0	0	-	-	0	-	-	0	-	-
2220	1	1	0	-	-	0	-	-	0	-	-
2250	3	0	0	-	-	0	-	-	0	-	-
2260	0	0	0	-	-	0	-	-	0	-	-
2310	1	0	1	0.25	-	0	-	-	1	0.25	-
3310	5	6	0	-	-	0	-	-	0	-	-
3320	6	4	0	-	-	1	0.23	-	1	0.23	-

(1) Number of stations with perennial streamflow.
(2) Number of stations with intermittent streamflow.
(3) Number of stations with cutthroat trout.
(4) Number of stations with brook trout.
(5) Number of stations with trout.

Trout were found in two of the six fluvial valley-bottom types. Cutthroat trout were found in only one station in the 1210 VBT although three stations with sufficient discharge to maintain trout were sampled. Trout were found in all stations in the 1220 VBT. No stations were established in the 2210 VBT of the NFH study area, which contained only 0.6 miles of perennial stream. No were trout found in the 2220 VBT, where most streams are intermittent. No trout were found in the 2250 and 2260 VBTs. Although mostly perennial, discharge in these notch-shaped fluvial canyons fluctuates in response to irrigation withdrawals.

Trout were mostly absent in survey stations located in alluvial valley-bottom types. The two exceptions are one station (PI04) in the 2310 VBT, which was located near the boundary with a 1220 VBT, and one station (NF06A) in the 3320 VBT, which was transitional to the 1130 VBT. Perennial streams in alluvial lands, most of which are private land, are impacted by agriculture, willow eradication, reduced flow during the irrigation season and intensive livestock grazing. The average condition rating (scale: 1=best; 4=worst) for stations with perennial streamflow located in alluvial lands was 2.69 (standard deviation = 0.51).

Population attributes for cutthroat and brook trout and stream dimensions for survey stations in the NFH study area are summarized in Table 5.5-2 (see Figure 3.4-1 for locations of survey stations). Valley-bottom type (VBT) and condition rating (calculated from clustering and discriminant functions) are also listed. Linear regression and analysis of variance were used to test for significant correlations between trout biomass/unit area and condition ratings of survey stations, first for all stations where trout were present, then for stations in each valley-bottom type where trout were present. Results are listed in Table 5.5-3.

The correlation between trout biomass/unit area and condition ratings was not significant for all stations where trout were found. Neither was the correlation significant for glacial trains (1120 VBT). All stations in the 1120 VBT have similar condition ratings (average rating = 2.75; standard deviation = 0.08). The number of stations with fish was insufficient for analyses of correlation for the 1130, 1210, 2310 and 3320 VBTs.

Table 5.5-1. Summary of fish attributes.

	STATION							CUTTRHOAT					BROOK TROUT					TROUT	
CODE	VBT	RATING	L (1)	WDT (2)	AREA (3)	DEPTH (4)	VOL (5)	POP (6)	LENGTH (7)	BM (8)	BM/A (9)	BM/V (10)	POP (6)	LENGTH (7)	BM (8)	BM/A (9)	BM/V (10)	BM/A (9)	BM/V (10)
FM02	3320	2.09	750	0.0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
FM05	1130	2.70	300	8.6	2580	0.2	516	6	120	127	0.05	0.25	0	0	0	0	0	0.05	0.25
FM06	1120	2.83	330	8.4	2772	0.3	831.6	98	117	2068	0.75	2.49	0	0	0	0	0	0.75	2.49
FM07	1120	2.64	360	8.8	3168	0.3	950.4	69	114	1395	0.44	1.47	0	0	0	0	0	0.44	1.47
FM08	1120	2.75	450	6.0	2700	0.3	810	104	105	1717	0.64	2.12	0	0	0	0	0	0.64	2.12
FM09	1120	2.67	390	4.7	1833	0.2	366.6	24	87	199	0.11	0.54	0	0	0	0	0	0.11	0.54
GZ01	3320	2.56	300	3.3	990	0.2	198	0	0	0	0	0	0	0	0	0	0	0	0
GZ02	3310	2.67	750	4.1	3075	0.3	922.5	0	0	0	0	0	0	0	0	0	0	0	0
GZ03	3310	2.25	210	4.6	966	0.3	289.8	0	0	0	0	0	0	0	0	0	0	0	0
GZ04	3310	2.09	750	6.5	4875	0.3	1462.	0	0	0	0	0	0	0	0	0	0	0	0
GZ05	1220	3.42	420	6.5	2730	0.3	819	28	105	617	0.23	0.75	0	0	0	0	0	0.23	0.75
GZWM	1220	2.93	450	6.5	2925	0.3	877.5	54	127	1844	0.63	2.10	0	0	0	0	0	0.63	2.10
GZSA1	1220	2.13	600	6.1	3660	0.3	1098	186	82	2291	0.63	2.61	0	0	0	0	0	0.63	2.61
GZSA2	1220	1.96	600	5.7	3420	0.2	684	205	75	2066	0.60	3.02	0	0	0	0	0	0.60	3.02
GZSA3	1220	2.33	600	4.3	2580	0.2	516	272	68	1752	0.68	3.40	0	0	0	0	0	0.68	3.40
GZ06	1210	2.00	750	2.1	1575	0.1	157.5	0	0	0	0	0	0	0	0	0	0	0	0
PI01	2250	2.90	210	17.0	3570	0.9	3213	0	0	0	0	0	0	0	0	0	0	0	0
PI02	3320	2.95	450	17.9	8055	0.6	4833	0	0	0	0	0	0	0	0	0	0	0	0
PI03	3310	2.84	450	11.6	5220	0.5	2610	0	0	0	0	0	0	0	0	0	0	0	0
PI04	2310	2.13	570	1.8	1026	0.2	205.2	12	124	262	0.26	1.28	0	0	0	0	0	0.25	1.28
PI05	2220	2.43	300	2.9	870	0.1	87	0	0	0	0	0	0	0	0	0	0	0	0
PI06	1220	3.94	750	2.7	2025	0.2	405	0	0	0	0	0	0	0	0	0	0	0	0
PI07	1210	1.94	750	2.4	1800	0.2	360	0	0	0	0	0	0	0	0	0	0	0	0
PR04	1130	2.94	DRY	0.0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR05	1120	2.85	510	6.5	3315	0.2	663	0	0	0	0	0	98	104	2158	0.65	3.25	0.65	3.25
PR06	1120	2.73	450	5.9	2655	0.2	531	0	0	0	0	0	172	81	2424	0.91	4.56	0.91	4.56
PR06A	1110	0.00	DRY	0.0	0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0
PR07	1110	2.70	750	4.6	3450	0.2	690	0	0	0	0	0	0	0	0	0	0	0	0
NF01	2250	2.81	120	17.1	2052	0.4	820.8	0	0	0	0	0	0	0	0	0	0	0	0
NF03A	3320	2.68	750	12.8	9600	0.7	6720	0	0	0	0	0	0	0	0	0	0	0	0
NF04	2250	2.67	750	10.5	7875	0.5	3937.	0	0	0	0	0	0	0	0	0	0	0	0
NF05	3320	2.54	750	16.2	12150	0.5	6075	0	0	0	0	0	0	0	0	0	0	0	0
NF06	3320	2.20	750	11.0	8250	0.6	4950	0	0	0	0	0	0	0	0	0	0	0	0
NF06A	3320	2.96	630	7.2	4536	0.4	1814.	0	0	0	0	0	90	89	1026	0.23	0.56	0.23	0.56
NF07	3310	3.85	660	5.9	3894	0.2	778.8	0	0	0	0	0	0	0	0	0	0	0	0
NF08	1220	2.62	420	9.2	3864	0.3	1159.	3	160	139	0.04	0.12	11	114	283	0.07	0.24	0.11	0.36
NF09	1220	2.76	480	8.7	4176	0.3	1252.	32	115	548	0.13	0.44	49	111	1278	0.31	1.02	0.44	1.46
NF10	1220	2.71	450	6.5	2925	0.2	585	53	68	396	0.14	0.68	0	0	0	0	0	0.14	0.68
NF11	1220	2.69	390	7.1	2769	0.3	830.7	9	79	104	0.04	0.12	0	0	0	0	0	0.04	0.12
NF12	1220	2.85	750	3.7	2775	0.1	277.5	21	95	364	0.13	1.31	0	0	0	0	0	0.13	1.31
NF13	1210	2.83	210	3.6	756	0.1	75.6	7	89	131	0.17	1.73	0	0	0	0	0	0.17	1.73

(1) length of stream that was sampled (feet);
(2) average width of stream (feet);
(3) calculated area of stream (square feet);
(4) average depth of stream;
5) calculated volume of stream;
6) population estimate;
7) average length (mm);
8) estimated biomass (grams);
9) estimated biomass/unit area;
10) estimated biomass/unit volume;

Table 5.5-3. Results of tests for correlation between trout biomass/unit area and condition ratings of survey stations where trout were present.

VBT	N	Correlation Coefficient (R)	Significance
ALL	38	0.00	not significant
1120	5	0.40	not significant
1130	1	-	-
1210	1	-	-
1220	10	-0.56	significant ($p<0.05$)
2310	1	-	-
3320	1	-	-

A significant relationship between trout biomass/unit area and condition rating was found for the 1220 VBT. The regression equation is:

$$Y = 1.14 - 0.295X$$

where: Y = trout biomass/ft^2
X = condition rating from cluster and discriminant analyses

The negative coefficient of the condition rating indicates that trout biomass/unit area is inversely related to condition ratings (where higher numbers show worse condition). Trout biomass/unit area was generally greater in stations that were in better condition. Although significant, the degree of correlation was low (R^2 = 30.1). The range in condition ratings for the 10 stations was also low (1.96 to 2.85). The average condition rating for these stations was 2.64 (standard deviation = 0.42). Although we searched for stations that were in better condition, none were found in the NFH study area. Stations in the 1220 VBT with condition ratings greater than 3.0 were either dry or contained no trout.

Fish attributes were not particularly useful for assessing the condition of RRH in the NFH study area. Assessments were limited by the absence of RRH in good condition (rating < 2) for most valley-bottom types and the inherent variance in trout populations. Although reference stations in good condition were identified for some valley-bottom types outside the NFH study area, trout populations were not comparable due to differences in species composition, stocking and removal by fishermen.

Large fluctuations in trout populations and corresponding insignificant variations in habitat variables have been documented (Platts and Nelson 1988). The average fluctuation in cutthroat biomass/square meter (expressed as the percentage of average yearly values) measured over 8 years in the Gance Creek LFSA was 124 percent. Similar fluctuations (133 percent) were recorded for trout biomass/square meter measured over 6 years in the Tabor Creek LFSA (ibid.). These authors concluded that "trout populations are not necessarily stable entities (*even under consistent habitat conditions*) and should not be regarded as such."

6.0 SUMMARY

An approach was developed for identifying riverine/riparian habitat (RRH) of distinctive ecological potential and for assessing nonpoint source (nps) impacts. An approach is needed so that managers can evaluate compliance with the Clean Water Act and other laws to protect water and habitat values (section 1.0). The pilot study was intended for assessing the impacts of livestock (section 2.0); while the approach will be useful for assessing other nps impacts (e.g. roads, logging, crops), assessment criteria will need to be tailored to fit the mechanism through which the RRH is affected. The approach (section 2.1) entailed classification, mapping, measurement of attributes sensitive to livestock grazing, and statistical analyses to determine condition. The approach was tested in part of the Northern Basin and Range Ecoregion (see section 2.2). The target watershed was the North Fork Humboldt River in northern Nevada (section 2.3). A geographical information system (GIS) was used to generate maps and tabular summaries (section 3.0).

First, a hierarchical classification was developed to identify RRH of similar ecological potential (section 4.0). Maps and descriptions of ecoregions (section 4.1), geologic districts (section 4.2), landtype associations (section 4.3), valley-bottom landtypes (section 4.4), valley-bottom types (section 4.5) and landforms (section 4.6) were prepared. At the most precise level of hierarchy, vegetation types of similar existing state were identified (section 4.7). Supplemental maps and tabular summaries of landforms and vegetation types were provided in the Map Supplement Document. By referring to these maps and descriptions, the user can determine the class of RRH for any portion of the target watershed and can evaluate its functional characteristics in the context of broad-to-refined scale interpretations.

Next, an approach for assessment of RRH was developed (section 5.0). Attributes that were sensitive to livestock grazing were determined by comparing grazed versus rested pastures of Livestock/Fishery Study Areas in Nevada and Utah (sections 5.1 and 5.2). A simple model for assessing condition relative to a reference station, selected to represent the achievable state for a class of RRH, was also evaluated (see section 5.2). Applications of this simple model are limited by the scarcity of reference sites for many classes of RRH. In recourse, a hypothetical progression of states, ranging from near-natural to severely impacted, was suggested (section 5.3). Discriminant functions were used to relate measures of stream, channel and riparian attributes measured along transects in 110 survey stations to condition ratings corresponding with a progression of states. Relationships between bank-forming vegetation types and condition ratings were evaluated (section 5.4). Also, relationships between trout populations and condition ratings were evaluated (section 5.5). General conclusions, insights and limitations to the approach are summarized with respect to classification and assessment, respectively.

6.1 Classification Summary

The intent of the classification was to integrate the work of geologists, hydrologists, soil scientist and biologist into a useful system for land inventory and management. We assumed that streams and the landscapes where they occur are coevolutionary responses to the same processes. Landscapes of more similar evolutionary character, and inclusive of more similar RRH, were identified at successively more refined scales. This approach was useful for identifying classes of RRH of differing structure, function and ecological potential. Replicate sites in the same class are expected to respond similarly to management applications.

At the broadest level, **Ecoregions** (Omernik 1986) served as context for comparing RRH at a very broad (1:3,000,000) scale. Land-surface form, potential natural vegetation, land use and soil were used to distinguish the Northern Basin and Range Ecoregion, in which the pilot watershed is located. More intensive analyses at larger scales were used to develop an understanding of the variance within the pilot watershed.

Geologic districts comprised of similar rock types or parent materials were used to divide the pilot watershed into smaller compartments. They were useful for identifying landscapes of distinctive hydrologic character. Streams in different geologic districts responded at different rates or to different degrees to the same management. Differences were attributed to the rate of weathering and the size of weathering products (sediments). Differences in attainable water quality may also be attributed to geologic district. Geomorphic variables were used to identify areas of more similar potential within geologic districts.

Landtype associations are compartments within geologic districts that were distinguished by geomorphic variables. A geologic district may include glacial, fluvial, alluvial and/or lacustrine lands. Landtype associations are of more homogeneous hydrologic character. They generally respond to nps impacts through different mechanisms, or through the same mechanism at different rates or to different degrees. Streams in glacial lands with rubble substrate respond to overgrazing by an increase in channel width with little change in channel depth whereas streams in fluvial lands tend to incise. More subtle differences were observed between the same geomorphic class (e.g. fluvial land) in different geologic districts (e.g. sedimentary versus volcanic). Landtype associations can be further divided as landtypes.

Landtypes are identified by position in the context of landscapes and areas of distinctive evolutionary character. Measures of discrete variables (e.g. runoff potential) for landtypes are common inputs for hydrologic and erosional modelling of watersheds. Streams and riparian habitat occur in **valley-bottom landtypes**, the character of which varies between landtype associations. The area of the valley-bottom landtype, relative to landtype associations, also varies. Cattle spend more time in the valley-bottom where water, vegetation and shade are more abundant. The concentration of livestock in fluvial lands, where the valley-bottom comprises about 5 percent of the landscape, will be much higher than in alluvial lands, where the valley-bottom comprises nearly 20 percent of the landscape. The proportion of the valley-bottom landtype for different landtype associations may serve as a rough guide for adjusting livestock numbers to protect stream and riparian habitats.

The valley-bottom within a landtype association was partitioned into **valley-bottom types**, distinguished by the mode or relative effectiveness of geomorphic processes. For example, the valley-bottom in glacial lands can be divided into basins (zone of erosion), trains (zone of transport) and outwash plains (zone of deposition). Differences in the average gradient of same-order streams were evident between valley-bottom types in the same landtype association. Differences in the flow dynamics of streams and relationships between streams and alluvial groundwater were also apperent. These differences affect the linkages between riverine and riparian components and are of fundamental importance for impact assessments. Valley-bottom types were further partitioned into landforms.

Viewed from an evolutionary perspective, **landforms** are areas of more similar potential within a valley-bottom type: soils and potential natural vegetation on alluvial fans are different from those on floodplains and levees. Viewed from a management perspective, landforms may reflect the existing state (i.e. they may change from one type into another in response to land use): livestock grazing can cause erosion of streambanks, leading to enlarged stream channels at the expense of floodplains and levees. Viewed in context with stream and channel characteristics (e.g. graded versus incised), the potential natural communities of landforms can be ascertained. Where bank-forming, floodplains and levees are inherently more stable than alluvial fans and residual slopes; floodplains and levees may be more sensitive for assessing livestock impacts to streambanks.

Vegetation types were identified by physiognomic class (i.e. forested, shrub, herbaceous, substrate), water regime (e.g. seasonally flooded), and dominant plant species in overstory and understory canopies. For given channel conditions (e.g. graded), they generally correlate with landforms: shrub types are common on levees while floodplains are mostly herbaceous. Vegetation types in the pilot watershed (and throughout much of the West) have been altered by cultural impacts. Streamside vegetation has been replaced by streambars due to livestock trampling. Disturbance leading to channel incision results in lowering of alluvial water levels and encroachment of upland vegetation onto floodplains. Vegetation types can change in response to land use. An additional 130 plant communities were described in a subsequent study (Jensen and Ryel in progress) and will be used to refine descriptions of vegetation types. It is likely that vegetation types (see APPENDIX M) will be combined into fewer, more inclusive classes.

Classes of RRH identified in the target watershed recur throughout northern Nevada. The classification and inventory may serve as a basis for extrapolating information within the target watershed or to areas of the same class outside the target watershed. Classes identified in the target watershed are not inclusive of all classes in the Northern Basin and Range Ecoregion. Subsequently studies are needed to prepare a comprehensive legend of geologic districts, landtype associations, and valley-bottom types.

The advantages in the proposed system of classification are two: first, it is applied from the top down, using established, broad categories to organize more precise groups, thus giving a comparable base for field study; and second, it proceeds to account for variance at the broadest possible level. If large differences between habitats can be explained by different parent rock at the level of **geologic districts** (with consequent differences in erodibility, drainage, etc.) then there may be little need to consider vegetation types at the most-precise level to support a management decision. Precise inventories of vegetation types will be more understandable and comparable if broader levels of classification have accounted for variance beyond the scope of localized study.

Rosgen (1985) classified streams according to discrete ranges of continuous variables (e.g. gradient, sinuosity, substrate) to predict functional properties of the landscape; he views the system from the bottom-up (specific-to-general). We identified landscapes of similar functional character that included streams with discrete ranges of continuous variables; we view the system from top-down (general-to-specific). Variables that Rosgen used to classify streams are attributes (not criteria) for classes of RRH. Assuming that both classifications are founded on the same functional criteria and that streams and landscapes are coevolutionary

responses to the same processes, classes of RRH should include similar stream types, as classified by Rosgen. Measures of continuous variables (e.g. gradient, sinuosity, substrate) for stream reaches in a valley-bottom type were generally distinctive, but inclusive of a broader range than Rosgen's stream types. The range of continuous variables within a class of RRH could be used to improve criteria used to define stream types.

A subsequent study funded by Freeport McMoRan Gold Company is ongoing in the vicinity of the target watershed (Jensen and Ryel in progress). The existing inventory will be expanded to include about 300 square miles contiguous to the target watershed. Landforms and vegetation types were mapped from 1:3,000 scale aerial photos for an additional 70 miles of stream. Results will be used for assessing cumulative impacts to streams and riparian habitats. Results will be integrated with those of the Pilot Study and reported in 1990.

A similar approach to classification and inventory was applied in the watershed of Thousand Springs Creek (near Wells, Nevada) to predict the effects of groundwater depletion upon wetland habitats and to evaluate restoration potential (Jensen 1989). The same approach was also suggested for identifying areas that will respond similarly (or differently) to restoration practices (Jensen and Platts 1989).

Assumptions used in broad policy decisions need to be supported; without accurate, well-designed inventories, such decisions are a game of political blind-man's bluff. As we know, proper resource management doesn't always accord with political whim, though the task of land management is to reconcile the two. This study aims toward a regional integration of policy with a system of classification and inventory from which the condition of RRH can be assessed.

6.2 Assessment Summary

Comparisons between control (rested) and treatment (grazed) pastures of Livestock/Fishery Study Areas (LFSAs) were used to evaluate the sensitivity of stream, channel and riparian attributes. Differences in the width of streambars and the frequency of eroded banks were observed between some grazed and rested pastures. While these findings indicated that livestock impacts may be reflected in channel morphology and streambank stability, they were of limited value for assessing condition.

Subsequent analyses of a more comprehensive set of stream, channel and riparian attributes measured in LFSAs were conducted. Twelve stations (comprising four LFSAs) of similar geographical character were compared with a reference station, selected to represent the attainable state. Analysis of variance was used to test for differences between reference and treatment stations for each of 35 attributes. Results indicated that 24 attributes measured in the reference station were significantly different from those measured in half or more of the treatment stations; 10 attributes were different from all treatment stations. Differences in stream and channel attributes were also observed among different bank-forming landforms within the same treatment station. A simple model was used to rate the condition of treatment stations relative to the reference. While the results of this model were generally congruent with field observations and management history, its application is limited by the lack of representative reference sites.

An alternative approach to assessment relative to a progression of states was developed. Two progressions were recognized: that leading to an increase in channel depth (incised channel), often with a corresponding increase in channel width; and 2) that leading to an increase in channel

width with little change in depth (overbroadened channel). The former progression best characterizes fluvial and alluvial lands, while glacial lands tend to follow the latter progression. The progressions were described in terms of four states, ranging from near natural to severely impacted, and two recovery states.

Cluster and discriminant analyses were used to relate stream, channel and riparian attributes measured along transects to a progression of states. Each transect received a score, corresponding with a state. The condition rating for the survey station was the average score for the 25 transects. Mean values for attributes for the groups determined by cluster and discriminant analyses correlated with the hypothetical progression of states quite well, despite being independently derived. Condition ratings were also congruent with field observations and known management histories. By relating condition ratings to the progression of states, the effects of ongoing (or alternative) management could be projected. Discriminant functions developed in this approach can also be used to evaluate other survey stations.

While assessments relative to a progression of states were found useful for assessing condition and trend of survey stations, using this method for assessing stream continua was cumbersome, in that it required measurement of numerous attributes in many survey stations. In a subsequent study (Jensen and Ryel in progress) we identified a subset of attributes for discerning between specific states. For the former progression, streambank stability distinguished the impacted state; depth of channel distinguished incised streams; a combination of channel width and depth were used to distinguish severely impacted (blown out) reaches. These criteria were used to map states at 1:3,000 scale for entire tributaries. Using this approach, the average state for a stream could be determined. Survey stations will be to

evaluate the accuracy of occular assessments. Assessments based on interpretations of large (1:3,000) scale aerial photos are also being evaluated. Preliminary results are incouraging. Results will be reported in 1990.

General relationships between bank-forming vegetation types and condition ratings of survey stations were apparent. The more hydric (wetter) bank-forming vegetation types were generally associated with better condition. Although trout biomass was significantly correlated with condition ratings, the strength of the relationship was low. Fish attributes measured during only one season are not particularly useful for assessing the condition of RRH due to the high variance inherent to population dynamics.

Assessments relative to a progression of states were useful for identifying grazing impacts to stream and riparian habitats. Logging in the granite batholith in central Idaho may cause increased sediment input to streams and filling of pools with sand. Attributes used to assess livestock impacts (mostly streambank and channel attributes) will be of little use for evaluating the effects of logging. While the approach to assessment will be useful for assessing other nps impacts (e.g. logging, roads, crop agriculture, etc.), assessment criteria will need to be tailored to fit the mechanism of the impact.

7.0 LITERATURE CITED

Armour, C.L., Burnham, K.P. and W.S. Platts. 1983. Field methods and statistical analyses for monitoring small salmonid streams. USDI Fish and Wildlife Service. FWS/OBS-83/33. 200 pp.

Blackwelder, E. 1934. Supplementary notes on Pleistocene glaciation in the Great Basin. Wash. Acad. Sci. J., 24:217-222.

Brunsfeld, S.J. and F.D. Johnson. 1985. Field guide to willows of east-central Idaho. Forest, Wildlife and Range Experiment Station. University of Idaho, Moscow, ID. 95 pp.

Bureau of Land Management. 1986. Draft BLM riparian area management policy. Paper presented at BLM Riparian Management Workshop. June 3-4, 1986. Helena, MT. 4 pp.

Coats, R.R. 1987b. Geology of Elko County, Nevada. Bulletin 101. (Includes a 1:250,000 scale geologic map). Nevada Bureau of Mines and Geology and U.S. Geological Survey. University of Nevada-Reno, Reno, Nevada. 112 pp.

Coffin, P.D. 1982. Lahontan cutthroat trout fishery management plan for the Humboldt River drainage basin. Species Management Plan, Federal Aid Project F-20-17, Study IX Job Number 1-P-1. Reno, NV: State of Nevada, Department of Wildlife. 33 pp.

Cowardin, L.M., Carter, V., Golet, F.C. and E.T. Laroe. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS 79/31. U.S. Government Printing Office. Washington, D.C. 103 pp.

Cronquist, A., Holmgren, A.H., Holmgren, N.H., Reveal, J.L. and P.K. Holmgren. 1977. Intermountain Flora. Volume 6. Columbia University Press. New York. 584 pp.

Dutton, C.E. 1880. Geology of the High Plateaus of Utah. U.S. Government Printing Office. Washington, D.C.

Fenneman, N.M. 1931. Physiography of the western United States. McGraw-Hill, Inc., New York, NY. 534 pp.

Gerstung, E. 1982. Lahontan cutthroat trout. Outdoor California. July-August. p. 1-5.

Hansen, P.L., Chadde, S.W., and R.D. Pfister. 1987. Riparian dominance types of Montana. Montana Riparian Association, School of Forestry, University of Montana. Missoula, Montana. 357 pp.

Harvey, M.D., Watson, C.C., and S.A. Schumm. 1985. Gully Erosion. Bureau of Land Management, Technical Note 366. U.S. Government Printing Office. Washington, D.C. 181 pp.

Hintze, J.L. 1987. Number Cruncher Statistical System, Version 5.01; Reference Manual. Kaysville, Utah. 286 pp.

Hubbs, C.L., R.R. Miller, and L.C. Hubbs. 1974. Hydrologic history and relict fishes of the North-Central Great Basin, Volume VII. San Francisco, CA. California Academy of Sciences. 259 pp.

Hughes, R.M. and J.R. Gammon. 1986. Longitudinal changes in fish assemblages and water quality in the Williamette River, Oregon. Transactions of the American Fisheries Society. Vol. 116, No. 2, 196-209.

Hughes, R.M. Rextad, E. and C.E. Bond. 1987. The relationship of aquatic ecoregions, river basins and physiographic provinces to the Ichthyogeographic regions of Oregon. Coperia, 1987 (2), pp. 423-432.

Hunt, C.B. 1974. Natural Regions of the United States and Canada. W. H. Freeman and Co., San Francisco, CA. 725 pp.

Jensen, S.E. 1989. Classification, inventory, and assessment of wetland/riparian habitat, Thousand Springs Creek, Elko County, Nevada. Included in Thousand Springs Power Project EIS. BLM; Elko, NV.

Jensen, S.E. and W.S. Platts. 1989. Restoration of degraded riverine/riparian habitat in the Great Basin and Snake Regions. P. 377-416 in: (J.A. Kusler and M.E. Kentula eds.) Wetland Creation and Restoration: The Status of the Science. EPA600/3-89/038a. Environmental Research Laboratory; Corvallis, OR.

Jensen, S.E. and R. Ryel (in progress). Classification and assessment of riverine/riparian habitat in the North Fork Humboldt and Owyhee basins. Freeport-McMoRan Gold Company. Elko, NV.

Kovalchik, B.L. 1987. Riparian zone associations, Deschutes, Ochoco, Fremont, and Winema National Forests. R6 ECOL TP-279-87. USDA Forest Service, Pacific Northwest Region. 171 pp.

Kuchler, A.W. 1964. A potential natural vegetation of the coterminous United States. Amer. Geog. Soc. Spec. Publ. 361. 116 pp.

Larsen, D.P., Dudley, D.R. and R.M. Hughes. 1988. A regional approach for assessing attainable surface water quality: Ohio as a case study. Journal of Soil and Water Conservation.

Marshall, K. and M. C. Romesberg. 1977. CLUSTAR and CLUSTID - Programs for hierarchical cluster analysis. 65 p. IN: Henderson, J.A., Davis, L.S., and F.M. Ryberg (editors) ECOSYM: a classification and information system for wildland resource management. Utah State University, Logan, Utah.

Meinzer, O.E. 1922. Map of Pleistocene lakes of the Basin and Range Province and its significance. Bull. Geol. Soc. Am. 33: 541-552.

Mill, J.S. 1891. A system of logic, 8th ed. Harper and Bros., New York. 659 pp.

Motyka, J., Dobrzanski, B. and S. Zawadski. 1950. Wstepne badania nad lakami poludniowo-wschodneij Lubelszczyzny (Preliminary studies on meadows in the southeast of the province of Lublin. Summary in English). Ann. Univ. M. Curie-Sklodowska, Sec. E. 5(13): 367-447.

Morrison, R.B. 1965. Quaternary geology of the Great Basin. p. 265-284 IN: Stokes, W.L. (ed.) Guidebook to the geology of Utah. Utah Geol. Soc. No. 20. Salt Lake City, Utah.

Mutz, K.M. and R. Graham. 1982. Riparian community type classification - Big Piney Ranger District, Wyoming. unpublished USFS document. 88 pp.

Mutz, K.M. and J. Queiroz. 1983. Riparian community classification for the Centennial Mountains and South Fork Salmon River, Idaho. Unpublished USFS document. 170 pp.

National Oceanic and Atmospheric Administration. 1986. Climatic data - Nevada. Vol. 101, No. 11. National Climatic Data Center. Asheville, North Carolina.

Norton, B.E., Tuhy, J., and S. Jensen. 1981. Riparian community classification for the Greys River, Wyoming. Unpublished USFS document. Ogden, Utah. 188 pp.

Omernik, J.M. 1987. Ecoregions of the conterminous United States. Annals of the Association of American Geographers. 77: 118-125.

Padgett, W.G. and M.E. Manning. 1988. Preliminary riparian community type classification for Nevada. USDA Forest Service, Intermountain Region, Ecology and Classification Program. Ogden, Utah. 44 pp. + appendices.

Padgett, W.G. and A.P Youngblood. 1986. Riparian community type classification of southern Utah. USDA Forest Service, Intermountain Region. 57 pp.

Platts, W.S. and R.L. Nelson. 1983. Population fluctuations and generic differentiation in the Humboldt cutthroat trout of Gance Creek, Nevada. Cal-Neva Wildlife Transactions. p. 15-19.

Platts, W.S., Megahan, W.F. and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. USDA Forest Service, Intermountain Research Station, General Technical Report INT-138. Ogden, Utah.

Platts, W.S. Jensen, S.E. and F.J. Smith. 1988a. Preliminary classification and inventory of riverine/riparian habitats, Big Creek livestock/fisheries study areas, Utah. Draft Report. U.S. Forest Service Intermountain Research Station. Boise, Idaho.

Platts, W.S. Jensen, S.E. and F.J. Smith. 1988b. Preliminary classification and inventory of riverine/riparian habitats, livestock/fisheries study areas, Nevada. U.S. Forest Service Intermountain Research Station. Boise, Idaho.

Platts, W.S. and R.L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluations. North American Journal of Fisheries Management. 8:333-345.

Platts, W.S., Armour, C., Booth, G.D., Bryant, M., Bufford, J.L., Cuplin, P., Jensen, S.E., Lienkaemper, G.W., Minshal, G.W., Monsen, S.B., Nelson, R.L., Sedell, J.R., and J.S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. General Technical Report INT-221. Intermountain Research Station; Boise, ID. 177 pp.

Rohm, C.M., Giese, J.W. and C.C. Bennett. 1987. Evaluation of an aquatic ecoregion classification of streams in Arkansas. Journal of Freshwater Ecology. Vol. 4, No. 1:127-140.

Rosgen, D.L. 1985. A stream classification system. In: Riparian ecosystems and their management; reconciling conflicting uses. First North American Riparian Conference. Tucson, AZ. (April 16-18, 1985). USDA, Forest Service, General Technical Report RM-120. p. 91-95.

Stewart, J.H. and J.E. Carlson. 1978. Geologic map of Nevada (1:500,000). U.S. Geological Survey and Nevada Bureau of Mines and Geology.

Tuhy, J.S. and S.Jensen. 1982. Riparian classification for the upper Salmon/Middle Fork Salmon Rivers, Idaho. Unpublished USFS document. 200 pp.

USDA-SCS. 1975. Soil Taxonomy - a basic system of soil classification for making and interpreting soil surveys. Handbook No. 436. U.S. Government Printing Office. Washington D.C. 754 pp.

USDA-SCS. 1979. Definitions and abbreviations for soil descriptions. West Technical Service Center. Portland, Oregon. 16 pp.

USDA-SCS. 1982. Soil Survey Manual. U.S. Government Printing Office. Washington D.C.

U.S. Fish and Wildlife Service. 1987. Wetland plant list - Intermountain Region. WELUT-87/W13.09. St. Petersburg, Florida.

U.S. Forest Service. 1985. Fisheries Habitat Surveys Handbook. Region 4-GSH 2609.23. Ogden, Utah. 194 pp.

Van Deventer, J.S. and W.S. Platts. In press. User's guide for Microfish 3.0, a software package for processing electrofishing data obtained by the removal method. USDA-Forest Service Intermountain Research Station, Boise, Idaho.

Welsh, S.L., Atwood, N.D., Higgins, L.C. and S. Goodrich. 1987. A Utah Flora. Brigham Young University Press. Provo, Utah. 894 pp.

Wertz, W.A. and J.F. Arnold. 1972. Land systems inventory. USDA Forest Service, Intermountain Region. Ogden, Utah.

Whittier, T.R., Hughes, R.M. and D.P. Larsen. 1988. The correspondence between ecoregions and spatial patterns in stream ecosystems in Oregon. Can. Jour. Fish. Aquat. Sci.

Youngblood, A.P., Padgett, W.G. and A.H. Winward. 1985. Riparian community type classification of eastern Idaho - western Wyoming. USFS, Intermountain Region. R4-Ecol-85-01. Ogden, Utah. 78 pp.